

P/ NT COOPERATION TREAT

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner
 US Department of Commerce
 United States Patent and Trademark
 Office, PCT
 2011 South Clark Place Room
 CP2/5C24
 Arlington, VA 22202
 ETATS-UNIS D'AMERIQUE
 in its capacity as elected Office

Date of mailing (day/month/year) 20 November 2000 (20.11.00)	
International application No. PCT/US00/03453	Applicant's or agent's file reference BB1321 PCT1
International filing date (day/month/year) 09 February 2000 (09.02.00)	Priority date (day/month/year) 10 February 1999 (10.02.99)
Applicant CARLSON, Thomas, J. et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:

30 August 2000 (30.08.00)

☐ in a notice effecting later election filed with the International Bureau on:2. The election ☒ was☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Olivia TEFY Telephone No.: (41-22) 338.83.38
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P NT COOPERATION TREATY

NOV 16 2000
RECEIVED

From th INTERNATIONAL SEARCHING AUTHORITY

PCT

NOV 10 2000

To:

E.I. DU PONT DE NEMOURS AND COMPANY
Legal/Patent Records Center
Attn. FEULNER, Gregory J.
1007 Market Street
Wilmington, Delaware 19898
UNITED STATES OF AMERICA

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NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL SEARCH REPORT
OR THE DECLARATION

(PCT Rule 44.1)

Applicant's or agent's file reference BB1321 PCT1	Date of mailing (day/month/year) 01/11/2000
International application No. PCT/US 00/ 03453	International filing date (day/month/year) 09/02/2000
Applicant E.I. DU PONT DE NEMOURS AND COMPANY et al.	

1. ☒ The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:

The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. ☐ The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. ☐ **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

TRB NOTED

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90bis.1 and 90bis.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Andria Overbeeke-Siepkens
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NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions, respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When?

Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How?

Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

NOTES TO FORM PCT/ISA/220 (continued)

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

- (i) the claim is unchanged;
- (ii) the claim is cancelled;
- (iii) the claim is new;
- (iv) the claim replaces one or more claims as filed;
- (v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."
2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."
3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."
4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international application is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments and any accompanying statement, under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the time of filing the amendments (and any statement) with the International Bureau, also file with the International Preliminary Examining Authority a copy of such amendments (and of any statement) and, where required, a translation of such amendments for the procedure before that Authority (see Rules 55.3(a) and 62.2, first sentence). For further information, see the Notes to the demand form (PCT/IPEA/401).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

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INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference BB1321 PCT1	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/US 00/ 03453	International filing date (day/month/year) 09/02/2000	(Earliest) Priority Date (day/month/year) 10/02/1999
Applicant E.I. DU PONT DE NEMOURS AND COMPANY et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 5 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☒ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☒ furnished subsequently to this Authority in computer readable form.

☒ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☒ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☒ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☐ the text is approved as submitted by the applicant.

☒ the text has been established by this Authority to read as follows:

PLANT UDP-GLUCOSE EPIMERASES

TRB NOTED

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

1
☐ None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 00/03453

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Claims 1-22 Partially.

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

1. Claims: 1-22 partially

An isolated polynucleotide comprising a sequence encoding a polypeptide of at least 90 amino acids that has at least 95% identity to SEQ ID NO:2,10,18, or the complement thereof. Said nucleotide sequence consisting of SEQ ID NO:1,9,17 and being derived from maize. Chimeric genes and host cells comprising said sequences.

A polypeptide of at least 90 amino acids having at least 95% identity to SEQ ID NO:2,10,18.

An isolated polynucleotide comprising at least 30 contiguous nucleotides derived from SEQ ID NO:1,9,17.

Methods for selecting an isolated polynucleotide that affects the level of UDP-galactose-4-epimerase polypeptide in a plant cell, for obtaining a nucleic acid fragment encoding a UDP-galactose-4-epimerase polypeptide, for positive selection of a transformed cell, all methods employing the said sequences and as described in the claims. Compositions comprising the said polynucleotides.

2. Claims: 1-22 partially

idem for SEQ ID NO:3,4,11,12,19,20 being derived from rice

3. Claims: 1-22 partially

idem for SEQ ID NO:5,6,13,14,21,22 being derived from soybean

4. Claims: 1-22 partially

idem for SEQ ID NO:7,8,15,16,23,24 being derived from wheat

INTERNATIONAL SEARCH REPORT

International Application No

PC 00/03453

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C12N15/61 C12N15/82 C12N9/90 C12N5/10 C12Q1/68
A01H5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C12N C12Q A01H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DÖRMANN ET AL: "The role of UDP-glucose epimerase in carbohydrate metabolism of Arabidopsis" PLANT JOURNAL, GB, BLACKWELL SCIENTIFIC PUBLICATIONS, OXFORD, vol. 13, no. 5, 1 March 1998 (1998-03-01), pages 641-652, XP002082772 ISSN: 0960-7412 the whole document ---	1-22
A	WO 98 54335 A (PEDERSEN STEEN GULDAGER ;DANISCO (DK); BRUNSTEDT JANNE (DK); JOERS) 3 December 1998 (1998-12-03) the whole document --- -/-	1-22

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- * & * document member of the same patent family

Date of the actual completion of the international search

11 July 2000

Date of mailing of the international search report

01.11.00

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Kania, T

INTERNATIONAL SEARCH REPORT

International Application No

PC 00/03453

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	LAKE MARC R ET AL: "Molecular cloning and characterization of a UDP-glucose-4-epimerase gene (galE) and its expression in pea tissues." PLANT PHYSIOLOGY AND BIOCHEMISTRY (PARIS), vol. 36, no. 8, August 1998 (1998-08), pages 555-562, XP000923481 ISSN: 0981-9428 the whole document ---	1-22
A	DÖRMANN ET AL: "Functional expression of Uridine 5'diphospho-glucose 4-epimerase (EC 5.1.3.2) from Arabidopsis thaliana in Saccharomyces cerevisiae and Escherichia coli" ARCHIVES OF BIOCHEMISTRY AND BIOPHYSICS,US,NEW YORK, US, vol. 327, 1996, pages 27-34, XP002076759 ISSN: 0003-9861 the whole document ---	1-22
P,X	WALBOT V.: "Maize EST AC AW267428" EBI DATABASE,6 January 2000 (2000-01-06), XP002142269 the whole document -----	18

INTERNATIONAL SEARCH REPORT

Informa patent family members

International Application No

PCT/US 00/03453

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9854335 A	03-12-1998	AU 7446398 A	30-12-1998
		BR 9809493 A	20-06-2000
		CN 1264428 T	23-08-2000
		EP 0983369 A	08-03-2000
		GB 2342920 A	26-04-2000

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REC'D 08 JUN 2001

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

14

Applicant's or agent's file reference BB1321 PCT1		FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US00/03453	International filing date (day/month/year) 09/02/2000	Priority date (day/month/year) 10/02/1999
International Patent Classification (IPC) or national classification and IPC C12N15/82		
Applicant E.I. DU PONT DE NEMOURS AND COMPANY et al.		

<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 6 sheets, including this cover sheet.</p> <p><input type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of sheets.</p>
<p>3. This report contains indications relating to the following items:</p> <ul style="list-style-type: none"> I <input checked="" type="checkbox"/> Basis of the report II <input type="checkbox"/> Priority III <input checked="" type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability IV <input type="checkbox"/> Lack of unity of invention V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement VI <input type="checkbox"/> Certain documents cited VII <input type="checkbox"/> Certain defects in the international application VIII <input type="checkbox"/> Certain observations on the international application

Date of submission of the demand 30/08/2000	Date of completion of this report 06.06.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Ury, A Telephone No. +49 89 2399 8411 

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/US00/03453

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1-31 as originally filed

Claims, No.:

1-22 as originally filed

Drawings, sheets:

1/3-3/3 as originally filed

Sequence listing part of the description, pages:

1-26, as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☒ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☒ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☒ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/US00/03453

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

- ☐ the entire international application.
- ☒ claims Nos. 1-22 (partially).

because:

- ☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):
- ☐ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):
- ☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.
- ☒ no international search report has been established for the said claims Nos. 1-22 (partially).

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

- ☐ the written form has not been furnished or does not comply with the standard.
- ☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/US00/03453

1. Statement

Novelty (N)	Yes:	Claims	1-6, 9-22
	No:	Claims	7, 8
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-22
Industrial applicability (IA)	Yes:	Claims	1-22
	No:	Claims	

2. Citations and explanations **see separate sheet**

Reference is made to the following documents:

- D1: DÖRMANN ET AL: 'The role of UDP-glucose epimerase in carbohydrate metabolism of Arabidopsis' PLANT JOURNAL,GB,BLACKWELL SCIENTIFIC PUBLICATIONS, OXFORD, vol. 13, no. 5, 1 March 1998 (1998-03-01), pages 641-652, XP002082772 ISSN: 0960-7412.
- D2: WO 98 54335 A (PEDERSEN STEEN GULDAGER ;DANISCO (DK); BRUNSTEDT JANNE (DK); JOERS) 3 December 1998 (1998-12-03).
- D3: LAKE MARC R ET AL: 'Molecular cloning and characterization of a UDP-glucose-4-epimerase gene (galE) and its expression in pea tissues.' PLANT PHYSIOLOGY AND BIOCHEMISTRY (PARIS), vol. 36, no. 8, August 1998 (1998-08), pages 555-562, XP000923481 ISSN: 0981-9428.
- D4: DÖRMANN ET AL: 'Functional expression of Uridine 5'diphospho-glucose 4-epimerase (EC 5.1.3.2) from Arabidopsis thaliana in Saccharomyces cerevisiae and Escherichia coli' ARCHIVES OF BIOCHEMISTRY AND BIOPHYSICS,US,NEW YORK, US, vol. 327, 1996, pages 27-34.

- I) SEQ ID NOs: 1, 9 and 17 are corn (maize) sequences. Maize cells contain these polynucleotide sequences. Thus, the host cells according to claims 7 and 8 lack novelty (Article 33.2 PCT) since they do not have any distinguishing technical feature which differentiates them from naturally occurring plant (maize) cells.
- II) Nucleic acid and polypeptide sequences encoding plant derived UDP-galactose-4-epimerases and recombinant uses thereof are disclosed in the prior art cited in the International Search Report (see e.g. D2 (guar), D3 (pea) and D1, D4 (Arabidopsis thaliana)).

The difference between the subject-matter as claimed and that of the above cited prior art is that the present claims are based on nucleic acid and polypeptide sequences encoding maize derived UDP-galactose-4-epimerase.

In the light of this prior art, the problem underlying the present application can be defined as the provision of further plant (e.g. maize) derived sequences encoding UDP-galactose-4-epimerase.



D3 teaches (Abstract and paragraph 2.1.) that the pea enzyme exhibits extensive homology with the sequences of Arabidopsis as well as with other prokaryotic and eukaryotic UDP-galactose-4-epimerases. D4 also teaches (fourth sentence of Abstract) a high degree of similarity between the UDP-galactose-4-epimerase of Arabidopsis and the UDP-galactose-4-epimerases from bacteria, rat and yeast.

Given this high level of sequence homology between UDP-galactose-4-epimerases from different origins and in particular amongst higher plants, the skilled person would have had more than a reasonable expectation of success in identifying further plant (e.g. maize) derived sequences encoding UDP-galactose-4-epimerase.

To do so, routine methods based on sequence similarities (such as for instance the method used by the applicant; see Example 2 of the description) were available to the skilled person.

Thus, the maize sequences of SEQ ID NOs 1,2, 9,10 and 17,18 do not involve an inventive step (Article 33.3 PCT).

The features recited in the claims not directly claiming the sequences per se, are either purely conventional or relate to obvious possibilities which do not appear to require any inventive skill (Article 33.3 PCT).

PATENT COOPERATION TREATY

RECEIVED

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

KENING LI
E.I. DUPONT DE NEMOURS AND COMPANY
Legal Patent Records Center
1007 Market Street
Wilmington, Delaware 19805
ETATS-UNIS D'AMERIQUE

PCT

JUN 12 2001

PATENT RECORDS
CENTER

NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL PRELIMINARY
EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing
(day/month/year)

06.06.2001

Applicant's or agent's file reference
BB1321 PCT1

IMPORTANT NOTIFICATION

International application No.
PCT/US00/03453

International filing date (day/month/year)
09/02/2000

Priority date (day/month/year)
10/02/1999

Applicant

E.I. DU PONT DE NEMOURS AND COMPANY et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.


4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/

 European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0 Tx: 523656 epmu d
Fax: +49 89 2399 - 4465

Authorized officer

CLEERE, C

Tel. +49 89 2399-8061

REY NOTED



10 JUL 2001

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)



Applicant's or agent's file reference BB1321 PCT1		FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/US00/03453	International filing date (day/month/year) 09/02/2000	Priority date (day/month/year) 10/02/1999	
International Patent Classification (IPC) or national classification and IPC C12N15/82			
Applicant E.I. DU PONT DE NEMOURS AND COMPANY et al.			

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 6 sheets, including this cover sheet.
 - ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 30/08/2000	Date of completion of this report 06.06.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Ury, A Telephone No. +49 89 2399 8411 

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/US00/03453

I. Basis of the report

1. With regard to the elements of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1-31 as originally filed

Claims, No.:

1-22 as originally filed

Drawings, sheets:

1/3-3/3 as originally filed

Sequence listing part of the description, pages:

1-26, as originally filed

2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
☐ the language of publication of the international application (under Rule 48.3(b)).
☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☒ contained in the international application in written form.
☐ filed together with the international application in computer readable form.
☐ furnished subsequently to this Authority in written form.
☒ furnished subsequently to this Authority in computer readable form.
☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
☒ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/US00/03453

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

- ☐ the entire international application.
- ☒ claims Nos. 1-22 (partially).

because:

- ☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):
- ☐ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):
- ☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.
- ☒ no international search report has been established for the said claims Nos. 1-22 (partially).

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

- ☐ the written form has not been furnished or does not comply with the standard.
- ☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/US00/03453

1. Statement

Novelty (N)	Yes:	Claims	1-6, 9-22
	No:	Claims	7, 8
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-22
Industrial applicability (IA)	Yes:	Claims	1-22
	No:	Claims	

2. Citations and explanations **see separate sheet**

Reference is made to the following documents:

- D1: DÖRMANN ET AL: 'The role of UDP-glucose epimerase in carbohydrate metabolism of Arabidopsis' PLANT JOURNAL, GB, BLACKWELL SCIENTIFIC PUBLICATIONS, OXFORD, vol. 13, no. 5, 1 March 1998 (1998-03-01), pages 641-652, XP002082772 ISSN: 0960-7412.
- D2: WO 98 54335 A (PEDERSEN STEEN GULDAGER ; DANISCO (DK); BRUNSTEDT JANNE (DK); JOERS) 3 December 1998 (1998-12-03).
- D3: LAKE MARC R ET AL: 'Molecular cloning and characterization of a UDP-glucose-4-epimerase gene (galE) and its expression in pea tissues.' PLANT PHYSIOLOGY AND BIOCHEMISTRY (PARIS), vol. 36, no. 8, August 1998 (1998-08), pages 555-562, XP000923481 ISSN: 0981-9428.
- D4: DÖRMANN ET AL: 'Functional expression of Uridine 5'diphospho-glucose 4-epimerase (EC 5.1.3.2) from Arabidopsis thaliana in Saccharomyces cerevisiae and Escherichia coli' ARCHIVES OF BIOCHEMISTRY AND BIOPHYSICS, US, NEW YORK, US, vol. 327, 1996, pages 27-34.

- I) SEQ ID NOs: 1, 9 and 17 are corn (maize) sequences. Maize cells contain these polynucleotide sequences. Thus, the host cells according to claims 7 and 8 lack novelty (Article 33.2 PCT) since they do not have any distinguishing technical feature which differentiates them from naturally occurring plant (maize) cells.
- II) Nucleic acid and polypeptide sequences encoding plant derived UDP-galactose-4-epimerases and recombinant uses thereof are disclosed in the prior art cited in the International Search Report (see e.g. D2 (guar), D3 (pea) and D1, D4 (Arabidopsis thaliana)).

The difference between the subject-matter as claimed and that of the above cited prior art is that the present claims are based on nucleic acid and polypeptide sequences encoding maize derived UDP-galactose-4-epimerase.

In the light of this prior art, the problem underlying the present application can be defined as the provision of further plant (e.g. maize) derived sequences encoding UDP-galactose-4-epimerase.

D3 teaches (Abstract and paragraph 2.1.) that the pea enzyme exhibits extensive homology with the sequences of Arabidopsis as well as with other prokaryotic and eukaryotic UDP-galactose-4-epimerases. D4 also teaches (fourth sentence of Abstract) a high degree of similarity between the UDP-galactose-4-epimerase of Arabidopsis and the UDP-galactose-4-epimerases from bacteria, rat and yeast.

Given this high level of sequence homology between UDP-galactose-4-epimerases from different origins and in particular amongst higher plants, the skilled person would have had more than a reasonable expectation of success in identifying further plant (e.g. maize) derived sequences encoding UDP-galactose-4-epimerase.

To do so, routine methods based on sequence similarities (such as for instance the method used by the applicant; see Example 2 of the description) were available to the skilled person.

Thus, the maize sequences of SEQ ID NOs 1,2, 9,10 and 17,18 do not involve an inventive step (Article 33.3 PCT).

The features recited in the claims not directly claiming the sequences per se, are either purely conventional or relate to obvious possibilities which do not appear to require any inventive skill (Article 33.3 PCT).

INTERNATIONAL SEARCH REPORT

International Application No
PL 00/03453

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C12N15/61 C12N15/82 C12N9/90 C12N5/10 C12Q1/68
A01H5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C12N C12Q A01H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DÖRMANN ET AL: "The role of UDP-glucose epimerase in carbohydrate metabolism of Arabidopsis" PLANT JOURNAL, GB, BLACKWELL SCIENTIFIC PUBLICATIONS, OXFORD, vol. 13, no. 5, 1 March 1998 (1998-03-01), pages 641-652, XP002082772 ISSN: 0960-7412 the whole document	1-22
A	WO 98 54335 A (PEDERSEN STEEN GULDAGER ;DANISCO (DK); BRUNSTEDT JANNE (DK); JOERS) 3 December 1998 (1998-12-03) the whole document	1-22

	-/--	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "Z" document member of the same patent family

Date of the actual completion of the international search

11 July 2000

Date of mailing of the international search report

01.11.00

Name and mailing address of the ISA

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NL - 2280 HV Rijswijk
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Fax: (+31-70) 340-3016

Authorized officer

Kania, T

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	LAKE MARC R ET AL: "Molecular cloning and characterization of a UDP-glucose-4-epimerase gene (galE) and its expression in pea tissues." PLANT PHYSIOLOGY AND BIOCHEMISTRY (PARIS), vol. 36, no. 8, August 1998 (1998-08), pages 555-562, XP000923481 ISSN: 0981-9428 the whole document ---	1-22
A	DÖRMANN ET AL: "Functional expression of Uridine 5'diphospho-glucose 4-epimerase (EC 5.1.3.2) from Arabidopsis thaliana in Saccharomyces cerevisiae and Escherichia coli" ARCHIVES OF BIOCHEMISTRY AND BIOPHYSICS,US,NEW YORK, US, vol. 327, 1996, pages 27-34, XP002076759 ISSN: 0003-9861 the whole document ---	1-22
P,X	WALBOT V.: "Maize EST AC AW267428" EBI DATABASE,6 January 2000 (2000-01-06), XP002142269 the whole document -----	18

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 00/03453

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Claims 1-22 Partially.

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

1. Claims: 1-22 partially

An isolated polynucleotide comprising a sequence encoding a polypeptide of at least 90 amino acids that has at least 95% identity to SEQ ID NO:2,10,18, or the complement thereof.

Said nucleotide sequence consisting of SEQ ID NO:1,9,17 and being derived from maize. Chimeric genes and host cells comprising said sequences.

A polypeptide of at least 90 amino acids having at least 95% identity to SEQ ID NO:2,10,18.

An isolated polynucleotide comprising at least 30 contiguous nucleotides derived from SEQ ID NO:1,9,17.

Methods for selecting an isolated polynucleotide that affects the level of UDP-galactose-4-epimerase polypeptide in a plant cell, for obtaining a nucleic acid fragment encoding a UDP-galactose-4-epimerase polypeptide, for positive selection of a transformed cell, all methods employing the said sequences and as described in the claims. Compositions comprising the said polynucleotides.

2. Claims: 1-22 partially

idem for SEQ ID NO:3,4,11,12,19,20 being derived from rice

3. Claims: 1-22 partially

idem for SEQ ID NO:5,6,13,14,21,22 being derived from soybean

4. Claims: 1-22 partially

idem for SEQ ID NO:7,8,15,16,23,24 being derived from wheat

INTERNATIONAL SEARCH REPORT

format patent family members

Intern Application No

PL, US 00/03453

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9854335 A	03-12-1998	AU 7446398 A	30-12-1998
		BR 9809493 A	20-06-2000
		CN 1264428 T	23-08-2000
		EP 0983369 A	08-03-2000
		GB 2342920 A	26-04-2000

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference BB1321 PCT1	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/US 00/ 03453	International filing date (day/month/year) 09/02/2000	(Earliest) Priority Date (day/month/year) 10/02/1999
Applicant E.I. DU PONT DE NEMOURS AND COMPANY et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 5 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:

☒ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☒ furnished subsequently to this Authority in computer readable form.

☒ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☒ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ Certain claims were found unsearchable (See Box I).

3. ☒ Unity of invention is lacking (see Box II).

4. With regard to the title,

☐ the text is approved as submitted by the applicant.

☒ the text has been established by this Authority to read as follows:

PLANT UDP-GLUCOSE EPIMERASES

5. With regard to the abstract,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the drawings to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

1
☐ None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 00/03453

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Claims 1-22 Partially.

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

1. Claims: 1-22 partially

An isolated polynucleotide comprising a sequence encoding a polypeptide of at least 90 amino acids that has at least 95% identity to SEQ ID NO:2,10,18, or the complement thereof. Said nucleotide sequence consisting of SEQ ID NO:1,9,17 and being derived from maize. Chimeric genes and host cells comprising said sequences.

A polypeptide of at least 90 amino acids having at least 95% identity to SEQ ID NO:2,10,18.

An isolated polynucleotide comprising at least 30 contiguous nucleotides derived from SEQ ID NO:1,9,17.

Methods for selecting an isolated polynucleotide that affects the level of UDP-galactose-4-epimerase polypeptide in a plant cell, for obtaining a nucleic acid fragment encoding a UDP-galactose-4-epimerase polypeptide, for positive selection of a transformed cell, all methods employing the said sequences and as described in the claims. Compositions comprising the said polynucleotides.

2. Claims: 1-22 partially

idem for SEQ ID NO:3,4,11,12,19,20 being derived from rice

3. Claims: 1-22 partially

idem for SEQ ID NO:5,6,13,14,21,22 being derived from soybean

4. Claims: 1-22 partially

idem for SEQ ID NO:7,8,15,16,23,24 being derived from wheat

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C12N15/61 C12N15/82 C12N9/90 C12N5/10 C12Q1/68
A01H5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C12N C12Q A01H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DÖRMANN ET AL: "The role of UDP-glucose epimerase in carbohydrate metabolism of Arabidopsis" PLANT JOURNAL, GB, BLACKWELL SCIENTIFIC PUBLICATIONS, OXFORD, vol. 13, no. 5, 1 March 1998 (1998-03-01), pages 641-652, XP002082772 ISSN: 0960-7412 the whole document	1-22
A	WO 98 54335 A (PEDERSEN STEEN GULDAGER ;DANISCO (DK); BRUNSTEDT JANNE (DK); JOERS) 3 December 1998 (1998-12-03) the whole document --- -/-	1-22

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

11 July 2000

Date of mailing of the international search report

01.11.00

Name and mailing address of the ISA

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Fax: (+31-70) 340-3016

Authorized officer

Kania, T

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	LAKE MARC R ET AL: "Molecular cloning and characterization of a UDP-glucose-4-epimerase gene (galE) and its expression in pea tissues." PLANT PHYSIOLOGY AND BIOCHEMISTRY (PARIS), vol. 36, no. 8, August 1998 (1998-08), pages 555-562, XP000923481 ISSN: 0981-9428 the whole document	1-22
A	--- DÖRMANN ET AL: "Functional expression of Uridine 5'diphospho-glucose 4-epimerase (EC 5.1.3.2) from Arabidopsis thaliana in Saccharomyces cerevisiae and Escherichia coli" ARCHIVES OF BIOCHEMISTRY AND BIOPHYSICS,US,NEW YORK, US, vol. 327, 1996, pages 27-34, XP002076759 ISSN: 0003-9861 the whole document	1-22
P,X	--- WALBOT V.: "Maize EST AC AW267428" EBI DATABASE,6 January 2000 (2000-01-06), XP002142269 the whole document -----	18

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 00/03453

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9854335 A	03-12-1998	AU 7446398 A	30-12-1998
		BR 9809493 A	20-06-2000
		CN 1264428 T	23-08-2000
		EP 0983369 A	08-03-2000
		GB 2342920 A	26-04-2000

INTERNATIONAL SEARCH REPORT

International Application No

PL, US 00/03453

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C12N15/61 C12N15/82 C12N9/90 C12N5/10 C12Q1/68
A01H5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C12N C12Q A01H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DÖRMANN ET AL: "The role of UDP-glucose epimerase in carbohydrate metabolism of Arabidopsis" PLANT JOURNAL, GB, BLACKWELL SCIENTIFIC PUBLICATIONS, OXFORD, vol. 13, no. 5, 1 March 1998 (1998-03-01), pages 641-652, XP002082772 ISSN: 0960-7412 the whole document	1-22
A	WO 98 54335 A (PEDERSEN STEEN GULDAGER ;DANISCO (DK); BRUNSTEDT JANNE (DK); JOERS) 3 December 1998 (1998-12-03) the whole document --- -/-	1-22

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

11 July 2000

Date of mailing of the international search report

01.11.00

Name and mailing address of the ISA

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Authorized officer

Kania, T

INTERNATIONAL SEARCH REPORT

International Application No

PL US 00/03453

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	LAKE MARC R ET AL: "Molecular cloning and characterization of a UDP-glucose-4-epimerase gene (galE) and its expression in pea tissues." PLANT PHYSIOLOGY AND BIOCHEMISTRY (PARIS), vol. 36, no. 8, August 1998 (1998-08), pages 555-562, XP000923481 ISSN: 0981-9428 the whole document	1-22
A	--- DÖRMANN ET AL: "Functional expression of Uridine 5'diphospho-glucose 4-epimerase (EC 5.1.3.2) from Arabidopsis thaliana in Saccharomyces cerevisiae and Escherichia coli" ARCHIVES OF BIOCHEMISTRY AND BIOPHYSICS,US,NEW YORK, US, vol. 327, 1996, pages 27-34, XP002076759 ISSN: 0003-9861 the whole document	1-22
P,X	--- WALBOT V.: "Maize EST AC AW267428" EBI DATABASE,6 January 2000 (2000-01-06), XP002142269 the whole document -----	18

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 00/03453

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Claims 1-22 Partially.

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.



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FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

1. Claims: 1-22 partially

An isolated polynucleotide comprising a sequence encoding a polypeptide of at least 90 amino acids that has at least 95% identity to SEQ ID NO:2,10,18, or the complement thereof.

Said nucleotide sequence consisting of SEQ ID NO:1,9,17 and being derived from maize. Chimeric genes and host cells comprising said sequences.

A polypeptide of at least 90 amino acids having at least 95% identity to SEQ ID NO:2,10,18.

An isolated polynucleotide comprising at least 30 contiguous nucleotides derived from SEQ ID NO:1,9,17.

Methods for selecting an isolated polynucleotide that affects the level of UDP-galactose-4-epimerase polypeptide in a plant cell, for obtaining a nucleic acid fragment encoding a UDP-galactose-4-epimerase polypeptide, for positive selection of a transformed cell, all methods employing the said sequences and as described in the claims. Compositions comprising the said polynucleotides.

2. Claims: 1-22 partially

idem for SEQ ID NO:3,4,11,12,19,20 being derived from rice

3. Claims: 1-22 partially

idem for SEQ ID NO:5,6,13,14,21,22 being derived from soybean

4. Claims: 1-22 partially

idem for SEQ ID NO:7,8,15,16,23,24 being derived from wheat

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PL, US 00/03453

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9854335 A	03-12-1998	AU 7446398 A	30-12-1998
		BR 9809493 A	20-06-2000
		CN 1264428 T	23-08-2000
		EP 0983369 A	08-03-2000
		GB 2342920 A	26-04-2000



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15/82, 9/90, 5/10, C12Q 1/68, A01H 5/00

(21) International Application Number: PCT/US00/03453

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(25) Filing Language: English

(26) Publication Language: English

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60/119,588 10 February 1999 (10.02.1999) US(71) Applicant (for all designated States except US): E.I. DU
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(72) Inventors; and

(75) Inventors/Applicants (for US only): CARLSON,
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[GB/GB]; 20 The Beeches, Woodhead Drive, Cambridge
CB4 1FY (GB).(74) Agent: FEULNER, Gregory, J.; E.I. du Pont de Nemours
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Street, Wilmington, DE 19898 (US).(81) Designated States (national): AE, AL, AU, BA, BB, BG,
BR, CA, CN, CR, CU, CZ, DM, EE, GD, GE, HR, HU, ID,
IL, IN, IS, JP, KP, KR, LC, LK, LR, LT, LV, MG, MK, MN,
MX, NO, NZ, PL, RO, SG, SI, SK, SL, TR, TT, UA, US,
UZ, VN, YU, ZA.(84) Designated States (regional): ARIPO patent (GH, GM,
KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent
(AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent
(AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU,

[Continued on next page]

(54) Title: PLANT UDP-GLUCOSE EPIMERASES

***** * * * * *

SEQ ID NO:25 MVASS-QKILVTGSAGFIGTHTVVQLLNNGFNVSIIIDNFDNSVMEAVERVREVGSNLSQ
SEQ ID NO:26 MSS---QTVLVTGGAGYIGSHTVLQLLGGFKAVVVDNLDNSSETAIHRVKELAGK-FAG
SEQ ID NO:14 MVSSS-QHILVTGGAGFIGTHTVVQLLKAGFSVSIIDNFDNSVMEAVDRVRQVVGPLLSQ
SEQ ID NO:16 ---AR-GSVLVTGGAGFIGTHTVLQLEKGYAVTAVDNFHNVSVEALDRVRHIVGPALSA
SEQ ID NO:18 T-----
SEQ ID NO:20 MVSALLRITLVTGGAGYIGSHTVLQLLQLGFRVVLDNLDNASELAILRVRELAGEH-NAN
SEQ ID NO:22 MRD---KTVLVTGGAGYIGSHTVLQLLGGFRAVVDNLDNLSSEVAIHRVRELAGE-FGN
1 60

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SEQ ID NO:25 NLEFTLGDLRNKDDLEKLFSSKSFDAVIHFAGLKAVGESVENPRRYFDNNLVGTINLYEV
SEQ ID NO:26 NLSFHKLDLRDRDALEKIFSSTKFDSVIHFAGLKAVGESVQKPLLYDNNLIGTIVLFEV
SEQ ID NO:14 NLQFTQGDLRNRDDLEKLFSSKTFDAVIHFAGLKAVAESVAKPRRYFDNLVGTINLYEF
SEQ ID NO:16 RLQFIQDGLTIKDDLEKVFAAKKYDAVIHFAGLKAVAESVAHPEMYNRRNIVGTIVNLYDV
SEQ ID NO:18 -----RIDLRDKGALEMVFASTRFEAVIHFAGLKAVGESVQKPLLYDNNVIGTINLLEV
SEQ ID NO:20 NLDFRKVDLRDKQALDQIFSSQRFDAVIHFAGLKAVGESVQKPLLYDNNLIGTITLLQV
SEQ ID NO:22 NLSFHKVDLRDRAALDQIFSSQRFDAVIHFAGLKAVGESVQKPLLYNNNLTGTITLLEV
61 120

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SEQ ID NO:25 MAKHNCKMVFSSSATVYGQPEKIPCEVEFKLOAMNPYGRTKLFLEEIARDIQKAEPEWR
SEQ ID NO:26 MAHGCKKLVFSSSATVYGLPKEVPCTEEFPLSAANPYGRTKLIIIEICRDIYRAEQEWK
SEQ ID NO:14 MAKYNCKMVFSSSATVYGQPEKIPCEVEFKLOAMNPYGRTKLFLEEIARDIQKAEPEWK
SEQ ID NO:16 MKKHGCKNLVFSSSATVYGQPEKVPCEFDSPLKALNPYGRTKLYLEMLRDYQHANPEWR
SEQ ID NO:18 MSVHGCKKLVFSSSAVYGSPPKNSPCTENFPLTPNNPYGKTKLVVEDICRDIYRSDPEWK
SEQ ID NO:20 MAHGCTKLVFSSSATVYGPKEVPCTEESPLCAMNPYGRTKLVIEDMCRDLHASDPNWK
SEQ ID NO:22 MAHGCKKLVFSSSATVYGPKEVPCTEEFPLSAMNPYGRTKLIIIEICROVRCAPEDPK
121 180

(57) Abstract: This invention relates to an isolated nucleic acid fragment encoding a UDP-galactose 4-epimerase. The invention also relates to the construction of a chimeric gene encoding all or a portion of the UDP-galactose 4-epimerase, in sense or antisense orientation, wherein expression of the chimeric gene results in production of altered levels of the UDP-galactose 4-epimerase in a transformed host cell.

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WO 00/47755 A3



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IL, IN, IS, JP, KP, KR, LC, LK, LR, LT, LV, MG, MK, MN,
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[Continued on next page]

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SEQ ID NO:14 MVSSS-QHILVTGGAGFIGTHTVVQLLKAGFSVSIIDNFDNSVMEAVDRVQVVGPLLSQ
SEQ ID NO:16 ---AR-GSVLVTGGAGFIGTHTVLQLLLEKGYAVTAVDNFNHNSVPEALDRVHIVGPALSA
SEQ ID NO:18 T-----
SEQ ID NO:20 MVSALLRTILVTGGAGYIGSHTVLQLLQLGFRVVVDNLDNASELAILRVRELAGH-NAN
SEQ ID NO:22 MRD---KTVLVTGGAGYIGSHTVLQLLGGFRAVVVDNLDNSSEVAIHRVRELAGE-FGN
1 60

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SEQ ID NO:25 NLEFTLGLDRNKDDLEKLFSSKFDVAIHFAGLKAVGESVENPRRYFDNNLVGTINLYEV
SEQ ID NO:26 NLSFHKLDLRDRDALEKIFSSSTKFDSVIHFAGLKAVGESVQKPLLYDNNLIGTIVLFEV
SEQ ID NO:14 NLQFTQGDLRNRDDLEKLFSSKTFDAIHFAGLKAVAESVAKPRRYFDNLVGTINLYEF
SEQ ID NO:16 RLQFI FGDLTIKDDLEKVFVAAKKYDAIHFAGLKAVAESVAHPMYNNRNVIGTVNLYDV
SEQ ID NO:18 -----RIDLRDKGALEMVFASTRFEAVIHFAGLKAVGESVQKPLLYDNNVIGTINLLEV
SEQ ID NO:20 NLDFRKVDLRDKQALDQIFSSQRFDAIHFAGLKAVGESVQKPLLYDNNLIGTITLLQV
SEQ ID NO:22 NLSFHKVDLRDRAALDQIFSSQRFDAIHFAGLKAVGESVQKPLLYNNNLTGTITLLEV
61 120

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SEQ ID NO:25 MAKHNCKKMVFSSSATVYGQPEKIPCVEDFKLQAMNPYGRTKLFLEEIARDIQKAEPEWR
SEQ ID NO:26 MAAHGCKKLVFSSSATVYGLPKEVPCTEEFPLSAANPYGRTKLIIIEICRDIYRAEQEWK
SEQ ID NO:14 MAKYNCKKMVFSSSATVYGQPEKIPCEEDFKLQAMNPYGRTKLFLEEIARDIQKAEPEWK
SEQ ID NO:16 MKKHGCKNKLVFSSSATVYGQPEKVPCEFSPLKALNPYGRTKLYLEMLRDYQHANPEWR
SEQ ID NO:18 MSVHGCKKLVFSSSAVYGSPPKNSPCTENFPLTPNNPYGRTKLVVEDICRDIYRSDPEWK
SEQ ID NO:20 MAAHGCTKLVFSSSATVYGPKEVPCTEESPLCAMNPYGRTKLVIEDMCRDLHASDPNWK
SEQ ID NO:22 MAAHGCKKLVFSSSATVYGPKEVPCTEEFPLSAMNPYGRTKLIIIEICRDVHCAEPDCK
121 180

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MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

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			(43) International Publication Date: 17 August 2000 (17.08.00)
(21) International Application Number: PCT/US00/03453		(74) Agent: FEULNER, Gregory, J.; E.I. du Pont de Nemours and Company, Legal Patent Records Center, 1007 Market Street, Wilmington, DE 19898 (US).	
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(30) Priority Data: 60/119,588 10 February 1999 (10.02.99) US		(81) Designated States: AE, AL, AU, BA, BB, BG, BR, CA, CN, CR, CU, CZ, DM, EE, GD, GE, HR, HU, ID, IL, IN, IS, JP, KP, KR, LC, LK, LR, LT, LV, MG, MK, MN, MX, NO, NZ, PL, RO, SG, SI, SK, SL, TR, TT, UA, US, UZ, VN, YU, ZA, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).	
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(75) Inventors/Applicants (for US only): CARLSON, Thomas, J. [US/US]; 2316 Orchard Road, Ardentown, DE 19810 (US). FADER, Gary, M. [US/US]; 1000 Woods Lane, Landenberg, PA 19350 (US). FAMODU, Omolayo, O. [US/US]; 216 Barrett Run Place, Newark, DE 19702 (US). KINNEY, Anthony, J. [GB/US]; 609 Lore Avenue, Wilmington, DE 19809 (US). PEARLSTEIN, Richard, W. [US/US]; 12 Canoe Court, Newark, DE 19702 (US). RAFALSKI, J., Antoni [US/US]; 2028 Longcome Drive, Wilmington, DE 19810 (US). THORPE, Catherine, J. [GB/GB]; 20 The Beeches, Woodhead Drive, Cambridge CB4 1FY (GB).			
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TITLE

UDP-GLUCOSE MODIFIERS

This application claims the benefit of U.S. Provisional Application No. 60/119,588, filed February 10, 1999.

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FIELD OF THE INVENTION

This invention is in the field of plant molecular biology. More specifically, this invention pertains to nucleic acid fragments encoding UDP-glucose modifiers in plants and seeds.

BACKGROUND OF THE INVENTION

10 Raffinose saccharides are a group of D-galactose-containing oligosaccharides of sucrose that are widely distributed in plants. Raffinose saccharides are characterized by having the general formula: [O- α -D-galactopyranosyl-(1 \rightarrow 6)_n- α -glucopyranosyl-(1 \rightarrow 2)- β -D-fructofuranoside where n=0 through n=4 are known respectively as sucrose, raffinose, stachyose, verbascose, and ajugose. The biosynthesis of raffinose saccharides has
15 been fairly well characterized [see Dey, P. M. In *Biochemistry of Storage Carbohydrates in Green Plants* (1985)]. The committed reaction of raffinose saccharide biosynthesis involves the synthesis of galactinol (O- α -D-galactopyranosyl-(1 \rightarrow 1)-*myo*-inositol) from UDP-galactose and *myo*-inositol. The enzyme that catalyzes this reaction is galactinol synthase. The flux of carbon through this reaction is controlled by the concentrations of the
20 two substrates for the enzyme. Thus, while they are not unique to the raffinose saccharide pathway, the enzymes which produce these substrates serve to limit carbon flux to the raffinose saccharides.

UDP-glucose 4-epimerase (EC 5.1.3.2) is also called UDP-galactose 4-epimerase. It is responsible for the interconversion of UDP-glucose and UDP-galactose. UDP-galactose is a
25 precursor of galactolipids and cell wall polysaccharides. When transgenic *Arabidopsis* plants expressing the UDP-glucose 4-epimerase gene in sense or antisense orientation are grown in soil, no changes in morphology or relative amounts of different galactose-containing compounds are detected. When the plants are grown on agar plates in the presence of galactose, a decrease in enzyme activity and an increase in the UDP-galactose
30 content correlates with a repression of growth while the UDP-glucose content does not change. Changes in the amount of galactose in the cell wall is detected in plants with low UDP-Glucose epimerase activity grown on galactose, while there is no change in the cellulose content of the leaves (Dormann and Benning (1998) *Plant J.* 13:641-652).

The activity of UDP-glucose 4-epimerase appears to be particularly limiting to carbon
35 flux into the raffinose saccharide pathway, therefore further reduction of the activity of this enzyme by tissue- and temporally-specific gene silencing should greatly decrease the levels of raffinose and stachyose in seeds.

Changes in the expression of either UDP-glucose 4-epimerase will allow the modification of the carbohydrate metabolism in transgenic plants. Modification of the expression of UDP-glucose 4-epimerase may result in grains with reduced cell-wall constituents (fiber) and increased levels of starch. This trait will add value for feed, food, and industrial applications of the crops.

SUMMARY OF THE INVENTION

Changes in the expression of UDP-glucose 4-epimerase will allow the modification of the carbohydrate metabolism in transgenic plants. Modification of the expression of UDP-glucose 4-epimerase may result in grains with reduced cell-wall constituents (fiber) and increased levels of starch. This trait will add value for feed, food, and industrial applications of the crops. For example, overexpression of UDP-glucose 4-epimerase in soybean should yield crops with lower contents of raffinose and stachyose and with significantly higher contents of sucrose.

The present invention relates to isolated polynucleotides comprising a nucleotide sequence encoding a polypeptide of at least 90 amino acids that has at least 95% identity based on the Clustal method of alignment when compared to a UDP-galactose 4-epimerase polypeptide selected from the group consisting of SEQ ID NOs:2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, and 24. The present invention also relates to an isolated polynucleotide comprising the complement of the nucleotide sequences described above.

It is preferred that the isolated polynucleotide of the claimed invention consists of a nucleic acid sequence selected from the group consisting of SEQ ID NOs:1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, and 23 that codes for the polypeptide selected from the group consisting of SEQ ID NOs:2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, and 24. The present invention also relates to an isolated polynucleotide comprising a nucleotide sequences of at least one of 60 (preferably at least one of 40, most preferably at least one of 30) contiguous nucleotides derived from a nucleotide sequence selected from the group consisting of SEQ ID NOs:1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23 and the complement of such nucleotide sequences.

The present invention relates to a chimeric gene comprising an isolated polynucleotide of the present invention operably linked to suitable regulatory sequences.

The present invention relates to an isolated host cell comprising a chimeric gene of the present invention or an isolated polynucleotide of the present invention. The host cell may be eukaryotic, such as a yeast or a plant cell, or prokaryotic, such as a bacterial cell. The present invention also relates to a virus, preferably a baculovirus, comprising an isolated polynucleotide of the present invention or a chimeric gene of the present invention.

The present invention relates to a process for producing an isolated host cell comprising a chimeric gene of the present invention or an isolated polynucleotide of the present invention, the process comprising either transforming or transfecting an isolated compatible host cell with a chimeric gene or isolated polynucleotide of the present invention.

The present invention relates to a UDP-galactose 4-epimerase polypeptide of at least 90 amino acids comprising at least 95% homology based on the Clustal method of alignment compared to a polypeptide selected from the group consisting of SEQ ID NOs:2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, and 24.

5 The present invention relates to a method of selecting an isolated polynucleotide that affects the level of expression of a UDP-galactose 4-epimerase polypeptide in a host cell, preferably a plant cell, the method comprising the steps of: (a) constructing an isolated polynucleotide of the present invention or an isolated chimeric gene of the present invention; (b) introducing the isolated polynucleotide or the isolated chimeric gene into a host cell;
10 (c) measuring the level a UDP-galactose 4-epimerase polypeptide in the host cell containing the isolated polynucleotide; and (d) comparing the level of a UDP-galactose 4-epimerase polypeptide in the host cell containing the isolated polynucleotide with the level of a UDP-galactose 4-epimerase polypeptide in the host cell that does not contain the isolated polynucleotide.

15 The present invention relates to a method of obtaining a nucleic acid fragment encoding a substantial portion of a UDP-galactose 4-epimerase polypeptide, preferably a plant UDP-galactose 4-epimerase polypeptide, comprising the steps of: synthesizing an oligonucleotide primer comprising a nucleotide sequence of at least one of 60 (preferably at least one of 40, most preferably at least one of 30) contiguous nucleotides derived from a
20 nucleotide sequence selected from the group consisting of SEQ ID NOs:1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23 and the complement of such nucleotide sequences; and amplifying a nucleic acid fragment (preferably a cDNA inserted in a cloning vector) using the oligonucleotide primer. The amplified nucleic acid fragment preferably will encode a portion of a UDP-galactose 4-epimerase amino acid sequence.

25 The present invention also relates to a method of obtaining a nucleic acid fragment encoding all or a substantial portion of the amino acid sequence encoding a UDP-galactose 4-epimerase polypeptide comprising the steps of: probing a cDNA or genomic library with an isolated polynucleotide of the present invention; identifying a DNA clone that hybridizes with an isolated polynucleotide of the present invention; isolating the identified DNA clone;
30 and sequencing the cDNA or genomic fragment that comprises the isolated DNA clone.

The present invention relates to a composition, such as a hybridization mixture, comprising an isolated polynucleotide of the present invention.

35 The present invention relates to an isolated polynucleotide of the present invention comprising at least one of 30 contiguous nucleotides derived from a nucleic acid sequence selected from the group consisting of SEQ ID NOs:1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, and the complement of such sequences.

The present invention relates to an expression cassette comprising an isolated polynucleotide of the present invention operably linked to a promoter.

The present invention relates to a method for positive selection of a transformed cell comprising: (a) transforming a host cell with the chimeric gene of the present invention or an expression cassette of the present invention; and (b) growing the transformed host cell, preferably plant cell, such as a monocot or a dicot, under conditions which allow expression of the UDP-galactose 4-epimerase polynucleotide in an amount sufficient to complement a null mutant to provide a positive selection means.

BRIEF DESCRIPTION OF THE DRAWING AND SEQUENCE DESCRIPTIONS

The invention can be more fully understood from the following detailed description and the accompanying drawing and Sequence Listing which form a part of this application.

Figure 2 shows a comparison of the amino acid sequences of the UDP-glucose 4-epimerase from soybean clone sls2c.pk017.k22: fis (SEQ ID NO:14), wheat clone wdk5c.pk006.o4: fis (SEQ ID NO:16), corn clone cen3n.pk0155.b8: fis (SEQ ID NO:18), rice clone rlr2.pk0043.c3: fis (SEQ ID NO:20), soybean clone se6.pk0014.f12 (SEQ ID NO:22), *Pisum sativum* (NCBI General Identifier No. 1173555, SEQ ID NO:25) and *Cyamopsis tetragonoloba* (NCBI General Identifier No. 3021357, SEQ ID NO:26). Amino acids conserved among all sequences are indicated by an asterisk (*) above the alignment. Dashes are used by the program to maximize the alignment.

Table 1 lists the polypeptides that are described herein, the designation of the cDNA clones that comprise the nucleic acid fragments encoding polypeptides representing all or a substantial portion of these polypeptides, and the corresponding identifier (SEQ ID NO:) as used in the attached Sequence Listing. The sequence descriptions and Sequence Listing attached hereto comply with the rules governing nucleotide and/or amino acid sequence disclosures in patent applications as set forth in 37 C.F.R. §1.821-1.825.

TABLE 1
UDP-Galactose 4-Epimerase

Protein	Clone Designation	SEQ ID NO:	
		(Nucleotide)	(Amino Acid)
Corn UDP-Galactose 4-Epimerase	cen3n.pk0155.b8	1	2
Rice UDP-Galactose 4-Epimerase	rlr2.pk0043.c3	3	4
Soybean UDP-Galactose 4-Epimerase	sls2c.pk017.k22	5	6
Wheat UDP-Galactose 4-Epimerase	wdk5c.pk006.o4	7	8
Corn UDP-Galactose 4-Epimerase	p0083.clddm72r	9	10
Rice UDP-Galactose 4-Epimerase	rls24.pk0008.d12	11	12
Soybean UDP-Galactose 4-Epimerase	sls2c.pk017.k22: fis	13	14

Protein	Clone Designation	SEQ ID NO:	
		(Nucleotide)	(Amino Acid)
Wheat UDP-Galactose 4-Epimerase	wdk5c.pk006.o4:fis	15	16
Corn UDP-Galactose 4-Epimerase	cen3n.pk0155.b8:fis	17	18
Rice UDP-Galactose 4-Epimerase	rlr2.pk0043.c3:fis	19	20
Soybean UDP-Galactose 4-Epimerase	se6.pk0014.f12	21	22
Wheat UDP-Galactose 4-Epimerase	wlm0.pk0015.g3	23	24

5 The Sequence Listing contains the one letter code for nucleotide sequence characters and the three letter codes for amino acids as defined in conformity with the IUPAC-IUBMB standards described in *Nucleic Acids Res.* 13:3021-3030 (1985) and in the *Biochemical J.* 219 (No. 2):345-373 (1984) which are herein incorporated by reference. The symbols and format used for nucleotide and amino acid sequence data comply with the rules set forth in 37 C.F.R. §1.822.

DETAILED DESCRIPTION OF THE INVENTION

10 In the context of this disclosure, a number of terms shall be utilized. As used herein, a “polynucleotide” is a nucleotide sequence such as a nucleic acid fragment. A polynucleotide may be a polymer of RNA or DNA that is single- or double-stranded, that optionally contains synthetic, non-natural or altered nucleotide bases. A polynucleotide in the form of a polymer of DNA may be comprised of one or more segments of cDNA, genomic DNA, 15 synthetic DNA, or mixtures thereof. An isolated polynucleotide of the present invention may include at least one of 60 contiguous nucleotides, preferably at least one of 40 contiguous nucleotides, most preferably one of at least 30 contiguous nucleotides derived from SEQ ID NOs:1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, or the complement of such sequences.

20 As used herein, “substantially similar” refers to nucleic acid fragments wherein changes in one or more nucleotide bases results in substitution of one or more amino acids, but do not affect the functional properties of the polypeptide encoded by the nucleotide sequence. “Substantially similar” also refers to nucleic acid fragments wherein changes in one or more nucleotide bases does not affect the ability of the nucleic acid fragment to 25 mediate alteration of gene expression by gene silencing through for example antisense or co-suppression technology. “Substantially similar” also refers to modifications of the nucleic acid fragments of the instant invention such as deletion or insertion of one or more nucleotides that do not substantially affect the functional properties of the resulting transcript vis-à-vis the ability to mediate gene silencing or alteration of the functional

properties of the resulting protein molecule. It is therefore understood that the invention encompasses more than the specific exemplary nucleotide or amino acid sequences and includes functional equivalents thereof.

Substantially similar nucleic acid fragments may be selected by screening nucleic acid fragments representing subfragments or modifications of the nucleic acid fragments of the instant invention, wherein one or more nucleotides are substituted, deleted and/or inserted, for their ability to affect the level of the polypeptide encoded by the unmodified nucleic acid fragment in a plant or plant cell. For example, a substantially similar nucleic acid fragment representing at least one of 30 contiguous nucleotides derived from the instant nucleic acid fragment can be constructed and introduced into a plant or plant cell. The level of the polypeptide encoded by the unmodified nucleic acid fragment present in a plant or plant cell exposed to the substantially similar nucleic fragment can then be compared to the level of the polypeptide in a plant or plant cell that is not exposed to the substantially similar nucleic acid fragment.

For example, it is well known in the art that antisense suppression and co-suppression of gene expression may be accomplished using nucleic acid fragments representing less than the entire coding region of a gene, and by nucleic acid fragments that do not share 100% sequence identity with the gene to be suppressed. Moreover, alterations in a nucleic acid fragment which result in the production of a chemically equivalent amino acid at a given site, but do not effect the functional properties of the encoded polypeptide, are well known in the art. Thus, a codon for the amino acid alanine, a hydrophobic amino acid, may be substituted by a codon encoding another less hydrophobic residue, such as glycine, or a more hydrophobic residue, such as valine, leucine, or isoleucine. Similarly, changes which result in substitution of one negatively charged residue for another, such as aspartic acid for glutamic acid, or one positively charged residue for another, such as lysine for arginine, can also be expected to produce a functionally equivalent product. Nucleotide changes which result in alteration of the N-terminal and C-terminal portions of the polypeptide molecule would also not be expected to alter the activity of the polypeptide. Each of the proposed modifications is well within the routine skill in the art, as is determination of retention of biological activity of the encoded products. Consequently, an isolated polynucleotide comprising a nucleotide sequence of at least one of 60 (preferably at least one of 40, most preferably at least one of 30) contiguous nucleotides derived from a nucleotide sequence selected from the group consisting of SEQ ID NOs:1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, and the complement of such nucleotide sequences may be used in methods of selecting an isolated polynucleotide that affects the expression of a UDP-galactose 4-epimerase polypeptide in a host cell. A method of selecting an isolated polynucleotide that affects the level of expression of a polypeptide in a host cell (eukaryotic, such as plant or yeast, prokaryotic such as bacterial, or viral) may comprise the steps of: constructing an isolated

polynucleotide of the present invention or an isolated chimeric gene of the present invention; introducing the isolated polynucleotide or the isolated chimeric gene into a host cell; measuring the level a polypeptide in the host cell containing the isolated polynucleotide; and comparing the level of a polypeptide in the host cell containing the isolated polynucleotide with the level of a polypeptide in a host cell that does not contain the isolated polynucleotide.

Moreover, substantially similar nucleic acid fragments may also be characterized by their ability to hybridize. Estimates of such homology are provided by either DNA-DNA or DNA-RNA hybridization under conditions of stringency as is well understood by those skilled in the art (Hames and Higgins, Eds. (1985) Nucleic Acid Hybridisation, IRL Press, Oxford, U.K.). Stringency conditions can be adjusted to screen for moderately similar fragments, such as homologous sequences from distantly related organisms, to highly similar fragments, such as genes that duplicate functional enzymes from closely related organisms. Post-hybridization washes determine stringency conditions. One set of preferred conditions uses a series of washes starting with 6X SSC, 0.5% SDS at room temperature for 15 min, then repeated with 2X SSC, 0.5% SDS at 45°C for 30 min, and then repeated twice with 0.2X SSC, 0.5% SDS at 50°C for 30 min. A more preferred set of stringent conditions uses higher temperatures in which the washes are identical to those above except for the temperature of the final two 30 min washes in 0.2X SSC, 0.5% SDS was increased to 60°C. Another preferred set of highly stringent conditions uses two final washes in 0.1X SSC, 0.1% SDS at 65°C.

Substantially similar nucleic acid fragments of the instant invention may also be characterized by the percent identity of the amino acid sequences that they encode to the amino acid sequences disclosed herein, as determined by algorithms commonly employed by those skilled in this art. Suitable nucleic acid fragments (isolated polynucleotides of the present invention) encode polypeptides that are at least about 70% identical, preferably at least about 80% identical to the amino acid sequences reported herein. Preferred nucleic acid fragments encode amino acid sequences that are about 85% identical to the amino acid sequences reported herein. More preferred nucleic acid fragments encode amino acid sequences that are at least about 90% identical to the amino acid sequences reported herein. Most preferred are nucleic acid fragments that encode amino acid sequences that are at least about 95% identical to the amino acid sequences reported herein. Suitable nucleic acid fragments not only have the above homologies but typically encode a polypeptide having at least 50 amino acids, preferably at least 100 amino acids, more preferably at least 150 amino acids, still more preferably at least 200 amino acids, and most preferably at least 250 amino acids. Sequence alignments and percent identity calculations were performed using the Megalign program of the LASERGENE bioinformatics computing suite (DNASTAR Inc., Madison, WI). Multiple alignment of the sequences was performed using the Clustal

method of alignment (Higgins and Sharp (1989) *CABIOS*. 5:151-153) with the default parameters (GAP PENALTY=10, GAP LENGTH PENALTY=10). Default parameters for pairwise alignments using the Clustal method were KTUPLE 1, GAP PENALTY=3, WINDOW=5 and DIAGONALS SAVED=5.

5 A “substantial portion” of an amino acid or nucleotide sequence comprises an amino acid or a nucleotide sequence that is sufficient to afford putative identification of the protein or gene that the amino acid or nucleotide sequence comprises. Amino acid and nucleotide sequences can be evaluated either manually by one skilled in the art, or by using computer-based sequence comparison and identification tools that employ algorithms such as BLAST
10 (Basic Local Alignment Search Tool; Altschul et al. (1993) *J. Mol. Biol.* 215:403-410; see also www.ncbi.nlm.nih.gov/BLAST/). In general, a sequence of ten or more contiguous amino acids or thirty or more contiguous nucleotides is necessary in order to putatively identify a polypeptide or nucleic acid sequence as homologous to a known protein or gene. Moreover, with respect to nucleotide sequences, gene-specific oligonucleotide probes
15 comprising 30 or more contiguous nucleotides may be used in sequence-dependent methods of gene identification (e.g., Southern hybridization) and isolation (e.g., *in situ* hybridization of bacterial colonies or bacteriophage plaques). In addition, short oligonucleotides of 12 or more nucleotides may be used as amplification primers in PCR in order to obtain a particular nucleic acid fragment comprising the primers. Accordingly, a “substantial portion” of a
20 nucleotide sequence comprises a nucleotide sequence that will afford specific identification and/or isolation of a nucleic acid fragment comprising the sequence. The instant specification teaches amino acid and nucleotide sequences encoding polypeptides that comprise one or more particular plant proteins. The skilled artisan, having the benefit of the sequences as reported herein, may now use all or a substantial portion of the disclosed
25 sequences for purposes known to those skilled in this art. Accordingly, the instant invention comprises the complete sequences as reported in the accompanying Sequence Listing, as well as substantial portions of those sequences as defined above.

 “Codon degeneracy” refers to divergence in the genetic code permitting variation of the nucleotide sequence without effecting the amino acid sequence of an encoded
30 polypeptide. Accordingly, the instant invention relates to any nucleic acid fragment comprising a nucleotide sequence that encodes all or a substantial portion of the amino acid sequences set forth herein. The skilled artisan is well aware of the “codon-bias” exhibited by a specific host cell in usage of nucleotide codons to specify a given amino acid. Therefore, when synthesizing a nucleic acid fragment for improved expression in a host cell,
35 it is desirable to design the nucleic acid fragment such that its frequency of codon usage approaches the frequency of preferred codon usage of the host cell.

 “Synthetic nucleic acid fragments” can be assembled from oligonucleotide building blocks that are chemically synthesized using procedures known to those skilled in the art.

These building blocks are ligated and annealed to form larger nucleic acid fragments which may then be enzymatically assembled to construct the entire desired nucleic acid fragment. "Chemically synthesized", as related to nucleic acid fragment, means that the component nucleotides were assembled *in vitro*. Manual chemical synthesis of nucleic acid fragments
5 may be accomplished using well established procedures, or automated chemical synthesis can be performed using one of a number of commercially available machines. Accordingly, the nucleic acid fragments can be tailored for optimal gene expression based on optimization of nucleotide sequence to reflect the codon bias of the host cell. The skilled artisan appreciates the likelihood of successful gene expression if codon usage is biased towards
10 those codons favored by the host. Determination of preferred codons can be based on a survey of genes derived from the host cell where sequence information is available.

"Gene" refers to a nucleic acid fragment that expresses a specific protein, including regulatory sequences preceding (5' non-coding sequences) and following (3' non-coding sequences) the coding sequence. "Native gene" refers to a gene as found in nature with its
15 own regulatory sequences. "Chimeric gene" refers any gene that is not a native gene, comprising regulatory and coding sequences that are not found together in nature. Accordingly, a chimeric gene may comprise regulatory sequences and coding sequences that are derived from different sources, or regulatory sequences and coding sequences derived from the same source, but arranged in a manner different than that found in nature.
20 "Endogenous gene" refers to a native gene in its natural location in the genome of an organism. A "foreign" gene refers to a gene not normally found in the host organism, but that is introduced into the host organism by gene transfer. Foreign genes can comprise native genes inserted into a non-native organism, or chimeric genes. A "transgene" is a gene that has been introduced into the genome by a transformation procedure.

25 "Coding sequence" refers to a nucleotide sequence that codes for a specific amino acid sequence. "Regulatory sequences" refer to nucleotide sequences located upstream (5' non-coding sequences), within, or downstream (3' non-coding sequences) of a coding sequence, and which influence the transcription, RNA processing or stability, or translation of the associated coding sequence. Regulatory sequences may include promoters, translation
30 leader sequences, introns, and polyadenylation recognition sequences.

"Promoter" refers to a nucleotide sequence capable of controlling the expression of a coding sequence or functional RNA. In general, a coding sequence is located 3' to a promoter sequence. The promoter sequence consists of proximal and more distal upstream elements, the latter elements often referred to as enhancers. Accordingly, an "enhancer" is a
35 nucleotide sequence which can stimulate promoter activity and may be an innate element of the promoter or a heterologous element inserted to enhance the level or tissue-specificity of a promoter. Promoters may be derived in their entirety from a native gene, or be composed of different elements derived from different promoters found in nature, or even comprise

synthetic nucleotide segments. It is understood by those skilled in the art that different promoters may direct the expression of a gene in different tissues or cell types, or at different stages of development, or in response to different environmental conditions. Promoters which cause a nucleic acid fragment to be expressed in most cell types at most
5 times are commonly referred to as "constitutive promoters". New promoters of various types useful in plant cells are constantly being discovered; numerous examples may be found in the compilation by Okamuro and Goldberg (1989) *Biochemistry of Plants* 15:1-82. It is further recognized that since in most cases the exact boundaries of regulatory sequences have not been completely defined, nucleic acid fragments of different lengths may have
10 identical promoter activity.

The "translation leader sequence" refers to a nucleotide sequence located between the promoter sequence of a gene and the coding sequence. The translation leader sequence is present in the fully processed mRNA upstream of the translation start sequence. The translation leader sequence may affect processing of the primary transcript to mRNA,
15 mRNA stability or translation efficiency. Examples of translation leader sequences have been described (Turner and Foster (1995) *Mol. Biotechnol.* 3:225-236).

The "3' non-coding sequences" refer to nucleotide sequences located downstream of a coding sequence and include polyadenylation recognition sequences and other sequences encoding regulatory signals capable of affecting mRNA processing or gene expression. The
20 polyadenylation signal is usually characterized by affecting the addition of polyadenylic acid tracts to the 3' end of the mRNA precursor. The use of different 3' non-coding sequences is exemplified by Ingelbrecht et al. (1989) *Plant Cell* 1:671-680.

"RNA transcript" refers to the product resulting from RNA polymerase-catalyzed transcription of a DNA sequence. When the RNA transcript is a perfect complementary
25 copy of the DNA sequence, it is referred to as the primary transcript or it may be a RNA sequence derived from posttranscriptional processing of the primary transcript and is referred to as the mature RNA. "Messenger RNA (mRNA)" refers to the RNA that is without introns and that can be translated into polypeptide by the cell. "cDNA" refers to a double-stranded DNA that is complementary to and derived from mRNA. "Sense" RNA
30 refers to an RNA transcript that includes the mRNA and so can be translated into a polypeptide by the cell. "Antisense RNA" refers to an RNA transcript that is complementary to all or part of a target primary transcript or mRNA and that blocks the expression of a target gene (see U.S. Patent No. 5,107,065, incorporated herein by reference). The complementarity of an antisense RNA may be with any part of the specific
35 nucleotide sequence, i.e., at the 5' non-coding sequence, 3' non-coding sequence, introns, or the coding sequence. "Functional RNA" refers to sense RNA, antisense RNA, ribozyme RNA, or other RNA that may not be translated but yet has an effect on cellular processes.

The term "operably linked" refers to the association of two or more nucleic acid fragments on a single nucleic acid fragment so that the function of one is affected by the other. For example, a promoter is operably linked with a coding sequence when it is capable of affecting the expression of that coding sequence (i.e., that the coding sequence is under the transcriptional control of the promoter). Coding sequences can be operably linked to regulatory sequences in sense or antisense orientation.

The term "expression", as used herein, refers to the transcription and stable accumulation of sense (mRNA) or antisense RNA derived from the nucleic acid fragment of the invention. Expression may also refer to translation of mRNA into a polypeptide.

"Antisense inhibition" refers to the production of antisense RNA transcripts capable of suppressing the expression of the target protein. "Overexpression" refers to the production of a gene product in transgenic organisms that exceeds levels of production in normal or non-transformed organisms. "Co-suppression" refers to the production of sense RNA transcripts capable of suppressing the expression of identical or substantially similar foreign or endogenous genes (U.S. Patent No. 5,231,020, incorporated herein by reference).

"Altered levels" refers to the production of gene product(s) in transgenic organisms in amounts or proportions that differ from that of normal or non-transformed organisms.

"Mature" protein refers to a post-translationally processed polypeptide; i.e., one from which any pre- or propeptides present in the primary translation product have been removed.

"Precursor" protein refers to the primary product of translation of mRNA; i.e., with pre- and propeptides still present. Pre- and propeptides may be but are not limited to intracellular localization signals.

A "chloroplast transit peptide" is an amino acid sequence which is translated in conjunction with a protein and directs the protein to the chloroplast or other plastid types present in the cell in which the protein is made. "Chloroplast transit sequence" refers to a nucleotide sequence that encodes a chloroplast transit peptide. A "signal peptide" is an amino acid sequence which is translated in conjunction with a protein and directs the protein to the secretory system (Chrispeels (1991) *Ann. Rev. Plant Phys. Plant Mol. Biol.* 42:21-53). If the protein is to be directed to a vacuole, a vacuolar targeting signal (*supra*) can further be added, or if to the endoplasmic reticulum, an endoplasmic reticulum retention signal (*supra*) may be added. If the protein is to be directed to the nucleus, any signal peptide present should be removed and instead a nuclear localization signal included (Raikhel (1992) *Plant Phys.* 100:1627-1632).

"Transformation" refers to the transfer of a nucleic acid fragment into the genome of a host organism, resulting in genetically stable inheritance. Host organisms containing the transformed nucleic acid fragments are referred to as "transgenic" organisms. Examples of methods of plant transformation include *Agrobacterium*-mediated transformation (De Blaere et al. (1987) *Meth. Enzymol.* 143:277) and particle-accelerated or "gene gun" transformation

technology (Klein et al. (1987) *Nature (London)* 327:70-73; U.S. Patent No. 4,945,050, incorporated herein by reference).

Standard recombinant DNA and molecular cloning techniques used herein are well known in the art and are described more fully in Sambrook et al. *Molecular Cloning: A Laboratory Manual*; Cold Spring Harbor Laboratory Press: Cold Spring Harbor, 1989 (hereinafter "Maniatis").

Nucleic acid fragments encoding at least a portion of several UDP-galactose 4-epimerases have been isolated and identified by comparison of random plant cDNA sequences to public databases containing nucleotide and protein sequences using the BLAST algorithms well known to those skilled in the art. The nucleic acid fragments of the instant invention may be used to isolate cDNAs and genes encoding homologous proteins from the same or other plant species. Isolation of homologous genes using sequence-dependent protocols is well known in the art. Examples of sequence-dependent protocols include, but are not limited to, methods of nucleic acid hybridization, and methods of DNA and RNA amplification as exemplified by various uses of nucleic acid amplification technologies (e.g., polymerase chain reaction, ligase chain reaction).

For example, genes encoding other UDP-galactose 4-epimerases, either as cDNAs or genomic DNAs, could be isolated directly by using all or a portion of the instant nucleic acid fragments as DNA hybridization probes to screen libraries from any desired plant employing methodology well known to those skilled in the art. Specific oligonucleotide probes based upon the instant nucleic acid sequences can be designed and synthesized by methods known in the art (Maniatis). Moreover, the entire sequences can be used directly to synthesize DNA probes by methods known to the skilled artisan such as random primer DNA labeling, nick translation, or end-labeling techniques, or RNA probes using available *in vitro* transcription systems. In addition, specific primers can be designed and used to amplify a part or all of the instant sequences. The resulting amplification products can be labeled directly during amplification reactions or labeled after amplification reactions, and used as probes to isolate full length cDNA or genomic fragments under conditions of appropriate stringency.

In addition, two short segments of the instant nucleic acid fragments may be used in polymerase chain reaction protocols to amplify longer nucleic acid fragments encoding homologous genes from DNA or RNA. The polymerase chain reaction may also be performed on a library of cloned nucleic acid fragments wherein the sequence of one primer is derived from the instant nucleic acid fragments, and the sequence of the other primer takes advantage of the presence of the polyadenylic acid tracts to the 3' end of the mRNA precursor encoding plant genes. Alternatively, the second primer sequence may be based upon sequences derived from the cloning vector. For example, the skilled artisan can follow the RACE protocol (Frohman et al. (1988) *Proc. Natl. Acad. Sci. USA* 85:8998-9002) to

generate cDNAs by using PCR to amplify copies of the region between a single point in the transcript and the 3' or 5' end. Primers oriented in the 3' and 5' directions can be designed from the instant sequences. Using commercially available 3' RACE or 5' RACE systems (BRL), specific 3' or 5' cDNA fragments can be isolated (Ohara et al. (1989) *Proc. Natl. Acad. Sci. USA* 86:5673-5677; Loh et al. (1989) *Science* 243:217-220). Products generated by the 3' and 5' RACE procedures can be combined to generate full-length cDNAs (Frohman and Martin (1989) *Techniques* 1:165). Consequently, a polynucleotide comprising a nucleotide sequence of at least one of 60 (preferably one of at least 40, most preferably one of at least 30) contiguous nucleotides derived from a nucleotide sequence selected from the group consisting of SEQ ID NOs:1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, and 23 and the complement of such nucleotide sequences may be used in such methods to obtain a nucleic acid fragment encoding a substantial portion of an amino acid sequence of a polypeptide. The present invention relates to a method of obtaining a nucleic acid fragment encoding a substantial portion of a UDP-galactose 4-epimerase polypeptide preferably a substantial portion of a plant UDP-galactose 4-epimerase polypeptide, comprising the steps of: synthesizing an oligonucleotide primer comprising a nucleotide sequence of at least one of 60 (preferably at least one of 40, most preferably at least one of 30) contiguous nucleotides derived from a nucleotide sequence selected from the group consisting of SEQ ID NOs:1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, and 23, and the complement of such nucleotide sequences; and amplifying a nucleic acid fragment (preferably a cDNA inserted in a cloning vector) using the oligonucleotide primer. The amplified nucleic acid fragment preferably will encode a portion of a UDP-galactose 4-epimerase polypeptide.

Availability of the instant nucleotide and deduced amino acid sequences facilitates immunological screening of cDNA expression libraries. Synthetic peptides representing portions of the instant amino acid sequences may be synthesized. These peptides can be used to immunize animals to produce polyclonal or monoclonal antibodies with specificity for peptides or proteins comprising the amino acid sequences. These antibodies can be then be used to screen cDNA expression libraries to isolate full-length cDNA clones of interest (Lerner (1984) *Adv. Immunol.* 36:1-34; Maniatis).

The nucleic acid fragments of the instant invention may be used to create transgenic plants in which the disclosed polypeptides are present at higher or lower levels than normal or in cell types or developmental stages in which they are not normally found. This would have the effect of altering the level of cell wall and starch biosynthesis in those cells. Modulation of the expression of UDP-galactose 4-epimerase can be used to control carbohydrate partitioning between cell wall and starch biosynthesis. Changes in the expression of UDP-glucose 4-epimerase will allow the modification of the carbohydrate metabolism in transgenic plants. Modification of the expression of UDP-glucose 4-epimerase may result in grains with reduced cell-wall constituents (fiber) and increased

levels of starch. This trait will add value for feed, food, and industrial applications of the crops. For example, overexpression of UDP-glucose 4-epimerase in soybean should yield crops with lower contents of raffinose and stachyose and with significantly higher contents of sucrose.

5 Overexpression of the proteins of the instant invention may be accomplished by first constructing a chimeric gene in which the coding region is operably linked to a promoter capable of directing expression of a gene in the desired tissues at the desired stage of development. The chimeric gene may comprise promoter sequences and translation leader sequences derived from the same genes. 3' Non-coding sequences encoding transcription
10 termination signals may also be provided. The instant chimeric gene may also comprise one or more introns in order to facilitate gene expression.

Plasmid vectors comprising the isolated polynucleotide (or chimeric gene) may be constructed. The choice of plasmid vector is dependent upon the method that will be used to transform host plants. The skilled artisan is well aware of the genetic elements that must be
15 present on the plasmid vector in order to successfully transform, select and propagate host cells containing the chimeric gene. The skilled artisan will also recognize that different independent transformation events will result in different levels and patterns of expression (Jones et al. (1985) *EMBO J.* 4:2411-2418; De Almeida et al. (1989) *Mol. Gen. Genetics* 218:78-86), and thus that multiple events must be screened in order to obtain lines
20 displaying the desired expression level and pattern. Such screening may be accomplished by Southern analysis of DNA, Northern analysis of mRNA expression, Western analysis of protein expression, or phenotypic analysis.

For some applications it may be useful to direct the instant polypeptides to different cellular compartments, or to facilitate its secretion from the cell. It is thus envisioned that
25 the chimeric gene described above may be further supplemented by directing the coding sequence to encode the instant polypeptides with appropriate intracellular targeting sequences such as transit sequences (Keegstra (1989) *Cell* 56:247-253), signal sequences or sequences encoding endoplasmic reticulum localization (Chrispeels (1991) *Ann. Rev. Plant Phys. Plant Mol. Biol.* 42:21-53), or nuclear localization signals (Raikhel (1992) *Plant Phys.* 100:1627-1632) with or without removing targeting sequences that are already present.
30 While the references cited give examples of each of these, the list is not exhaustive and more targeting signals of use may be discovered in the future.

It may also be desirable to reduce or eliminate expression of genes encoding the instant polypeptides in plants for some applications. In order to accomplish this, a chimeric
35 gene designed for co-suppression of the instant polypeptide can be constructed by linking a gene or gene fragment encoding that polypeptide to plant promoter sequences. Alternatively, a chimeric gene designed to express antisense RNA for all or part of the instant nucleic acid fragment can be constructed by linking the gene or gene fragment in

reverse orientation to plant promoter sequences. Either the co-suppression or antisense chimeric genes could be introduced into plants via transformation wherein expression of the corresponding endogenous genes are reduced or eliminated.

5 Molecular genetic solutions to the generation of plants with altered gene expression have a decided advantage over more traditional plant breeding approaches. Changes in plant phenotypes can be produced by specifically inhibiting expression of one or more genes by antisense inhibition or cosuppression (U.S. Patent Nos. 5,190,931, 5,107,065 and 5,283,323). An antisense or cosuppression construct would act as a dominant negative regulator of gene activity. While conventional mutations can yield negative regulation of
10 gene activity these effects are most likely recessive. The dominant negative regulation available with a transgenic approach may be advantageous from a breeding perspective. In addition, the ability to restrict the expression of specific phenotype to the reproductive tissues of the plant by the use of tissue specific promoters may confer agronomic advantages relative to conventional mutations which may have an effect in all tissues in which a mutant
15 gene is ordinarily expressed.

The person skilled in the art will know that special considerations are associated with the use of antisense or cosuppression technologies in order to reduce expression of particular genes. For example, the proper level of expression of sense or antisense genes may require the use of different chimeric genes utilizing different regulatory elements known to the
20 skilled artisan. Once transgenic plants are obtained by one of the methods described above, it will be necessary to screen individual transgenics for those that most effectively display the desired phenotype. Accordingly, the skilled artisan will develop methods for screening large numbers of transformants. The nature of these screens will generally be chosen on practical grounds. For example, one can screen by looking for changes in gene expression
25 by using antibodies specific for the protein encoded by the gene being suppressed, or one could establish assays that specifically measure enzyme activity. A preferred method will be one which allows large numbers of samples to be processed rapidly, since it will be expected that a large number of transformants will be negative for the desired phenotype.

The instant polypeptides (or portions thereof) may be produced in heterologous host
30 cells, particularly in the cells of microbial hosts, and can be used to prepare antibodies to these proteins by methods well known to those skilled in the art. The antibodies are useful for detecting the polypeptides of the instant invention *in situ* in cells or *in vitro* in cell extracts. Preferred heterologous host cells for production of the instant polypeptides are microbial hosts. Microbial expression systems and expression vectors containing regulatory
35 sequences that direct high level expression of foreign proteins are well known to those skilled in the art. Any of these could be used to construct a chimeric gene for production of the instant polypeptides. This chimeric gene could then be introduced into appropriate microorganisms via transformation to provide high level expression of the encoded

UDP-galactose 4-epimerase. An example of a vector for high level expression of the instant polypeptides in a bacterial host is provided (Example 6).

5 All or a substantial portion of the nucleic acid fragments of the instant invention may also be used as probes for genetically and physically mapping the genes that they are a part of, and as markers for traits linked to those genes. Such information may be useful in plant breeding in order to develop lines with desired phenotypes. For example, the instant nucleic acid fragments may be used as restriction fragment length polymorphism (RFLP) markers. Southern blots (Maniatis) of restriction-digested plant genomic DNA may be probed with the nucleic acid fragments of the instant invention. The resulting banding patterns may then
10 be subjected to genetic analyses using computer programs such as MapMaker (Lander et al. (1987) *Genomics* 1:174-181) in order to construct a genetic map. In addition, the nucleic acid fragments of the instant invention may be used to probe Southern blots containing restriction endonuclease-treated genomic DNAs of a set of individuals representing parent and progeny of a defined genetic cross. Segregation of the DNA polymorphisms is noted
15 and used to calculate the position of the instant nucleic acid sequence in the genetic map previously obtained using this population (Botstein et al. (1980) *Am. J. Hum. Genet.* 32:314-331).

The production and use of plant gene-derived probes for use in genetic mapping is described in Bernatzky and Tanksley (1986) *Plant Mol. Biol. Reporter* 4:37-41. Numerous
20 publications describe genetic mapping of specific cDNA clones using the methodology outlined above or variations thereof. For example, F2 intercross populations, backcross populations, randomly mated populations, near isogenic lines, and other sets of individuals may be used for mapping. Such methodologies are well known to those skilled in the art.

Nucleic acid probes derived from the instant nucleic acid sequences may also be used
25 for physical mapping (i.e., placement of sequences on physical maps; see Hoheisel et al. In: *Nonmammalian Genomic Analysis: A Practical Guide*, Academic press 1996, pp. 319-346, and references cited therein).

In another embodiment, nucleic acid probes derived from the instant nucleic acid sequences may be used in direct fluorescence *in situ* hybridization (FISH) mapping (Trask
30 (1991) *Trends Genet.* 7:149-154). Although current methods of FISH mapping favor use of large clones (several to several hundred KB; see Laan et al. (1995) *Genome Res.* 5:13-20), improvements in sensitivity may allow performance of FISH mapping using shorter probes.

A variety of nucleic acid amplification-based methods of genetic and physical mapping may be carried out using the instant nucleic acid sequences. Examples include
35 allele-specific amplification (Kazazian (1989) *J. Lab. Clin. Med.* 11:95-96), polymorphism of PCR-amplified fragments (CAPS; Sheffield et al. (1993) *Genomics* 16:325-332), allele-specific ligation (Landegren et al. (1988) *Science* 241:1077-1080), nucleotide extension reactions (Sokolov (1990) *Nucleic Acid Res.* 18:3671), Radiation Hybrid Mapping (Walter

et al. (1997) *Nat. Genet.* 7:22-28) and Happy Mapping (Dear and Cook (1989) *Nucleic Acid Res.* 17:6795-6807). For these methods, the sequence of a nucleic acid fragment is used to design and produce primer pairs for use in the amplification reaction or in primer extension reactions. The design of such primers is well known to those skilled in the art. In methods
5 employing PCR-based genetic mapping, it may be necessary to identify DNA sequence differences between the parents of the mapping cross in the region corresponding to the instant nucleic acid sequence. This, however, is generally not necessary for mapping methods.

Loss of function mutant phenotypes may be identified for the instant cDNA clones
10 either by targeted gene disruption protocols or by identifying specific mutants for these genes contained in a maize population carrying mutations in all possible genes (Ballinger and Benzer (1989) *Proc. Natl. Acad. Sci USA* 86:9402-9406; Koes et al. (1995) *Proc. Natl. Acad. Sci USA* 92:8149-8153; Bensen et al. (1995) *Plant Cell* 7:75-84). The latter approach may be accomplished in two ways. First, short segments of the instant nucleic acid
15 fragments may be used in polymerase chain reaction protocols in conjunction with a mutation tag sequence primer on DNAs prepared from a population of plants in which Mutator transposons or some other mutation-causing DNA element has been introduced (see Bensen, *supra*). The amplification of a specific DNA fragment with these primers indicates the insertion of the mutation tag element in or near the plant gene encoding the
20 instant polypeptides. Alternatively, the instant nucleic acid fragment may be used as a hybridization probe against PCR amplification products generated from the mutation population using the mutation tag sequence primer in conjunction with an arbitrary genomic site primer, such as that for a restriction enzyme site-anchored synthetic adaptor. With
25 either method, a plant containing a mutation in the endogenous gene encoding the instant polypeptides can be identified and obtained. This mutant plant can then be used to determine or confirm the natural function of the instant polypeptides disclosed herein.

EXAMPLES

The present invention is further defined in the following Examples, in which all parts and percentages are by weight and degrees are Celsius, unless otherwise stated. It should be
30 understood that these Examples, while indicating preferred embodiments of the invention, are given by way of illustration only. From the above discussion and these Examples, one skilled in the art can ascertain the essential characteristics of this invention, and without departing from the spirit and scope thereof, can make various changes and modifications of the invention to adapt it to various usages and conditions.

35

EXAMPLE 1

Composition of cDNA Libraries; Isolation and Sequencing of cDNA Clones

cDNA libraries representing mRNAs from various corn, rice, soybean, and wheat tissues were prepared. The characteristics of the libraries are described below.

TABLE 2
cDNA Libraries from Corn, Rice, Soybean, and Wheat

Library	Tissue	Clone
cen3n	Corn Endosperm 20 Days After Pollination*	cen3n.pk0155.b8
p0083	Corn Whole Kernels 7 Days After Pollination	p0083.clddm72r
rlr2	Rice Leaf 15 Days After Germination, 2 Hours After Infection of Strain <i>Magaporthe grisea</i> 4360-R-62 (AVR2-YAMO); Resistant	rlr2.pk0043.c3
rls24	Rice Leaf 15 Days After Germination, 24 Hours After Infection of Strain <i>Magaporthe grisea</i> 4360-R-67 (AVR2-YAMO); Susceptible	rls24.pk0008.d12
se6	Soybean Embryo, 26 Days After Flowering	se6.pk0014.f12
sls2c	Soybean Infected With <i>Sclerotinia sclerotiorum</i> Mycelium	sls2c.pk017.k22
wdk5c	Wheat Developing Kernel, 30 Days After Anthesis	wdk5c.pk006.o4
wlm0	Wheat Seedlings 0 Hour After Inoculation With <i>Erysiphe graminis f. sp tritici</i>	wlm0.pk0015.g3

- 5 cDNA libraries may be prepared by any one of many methods available. For example, the cDNAs may be introduced into plasmid vectors by first preparing the cDNA libraries in Uni-ZAP™ XR vectors according to the manufacturer's protocol (Stratagene Cloning Systems, La Jolla, CA). The Uni-ZAP™ XR libraries are converted into plasmid libraries according to the protocol provided by Stratagene. Upon conversion, cDNA inserts
- 10 will be contained in the plasmid vector pBluescript. In addition, the cDNAs may be introduced directly into precut Bluescript II SK(+) vectors (Stratagene) using T4 DNA ligase (New England Biolabs), followed by transfection into DH10B cells according to the manufacturer's protocol (GIBCO BRL Products). Once the cDNA inserts are in plasmid vectors, plasmid DNAs are prepared from randomly picked bacterial colonies containing
- 15 recombinant pBluescript plasmids, or the insert cDNA sequences are amplified via polymerase chain reaction using primers specific for vector sequences flanking the inserted cDNA sequences. Amplified insert DNAs or plasmid DNAs are sequenced in dye-primer sequencing reactions to generate partial cDNA sequences (expressed sequence tags or "ESTs"; see Adams et al., (1991) *Science* 252:1651-1656). The resulting ESTs are analyzed
- 20 using a Perkin Elmer Model 377 fluorescent sequencer.

EXAMPLE 2

Identification of cDNA Clones

- cDNA clones encoding UDP-galactose 4-epimerases were identified by conducting BLAST (Basic Local Alignment Search Tool; Altschul et al. (1993) *J. Mol. Biol.*
- 25 215:403-410; see also www.ncbi.nlm.nih.gov/BLAST/) searches for similarity to sequences contained in the BLAST "nr" database (comprising all non-redundant GenBank CDS

translations, sequences derived from the 3-dimensional structure Brookhaven Protein Data Bank, the last major release of the SWISS-PROT protein sequence database, EMBL, and DDBJ databases). The cDNA sequences obtained in Example 1 were analyzed for similarity to all publicly available DNA sequences contained in the "nr" database using the BLASTN algorithm provided by the National Center for Biotechnology Information (NCBI). The DNA sequences were translated in all reading frames and compared for similarity to all publicly available protein sequences contained in the "nr" database using the BLASTX algorithm (Gish and States (1993) *Nat. Genet.* 3:266-272) provided by the NCBI. For convenience, the P-value (probability) of observing a match of a cDNA sequence to a sequence contained in the searched databases merely by chance as calculated by BLAST are reported herein as "pLog" values, which represent the negative of the logarithm of the reported P-value. Accordingly, the greater the pLog value, the greater the likelihood that the cDNA sequence and the BLAST "hit" represent homologous proteins.

EXAMPLE 3

Characterization of cDNA Clones Encoding UDP-Galactose 4-Epimerase

The BLASTX search using the EST sequences from clones listed in Table 3 revealed similarity of the polypeptides encoded by the cDNAs to UDP-galactose 4-epimerase from *Pisum sativum* and *Cyamopsis tetragonoloba* (NCBI General Identifier No. 1173555 and 3021357, respectively). Shown in Table 3 are the BLAST results for individual ESTs ("EST"):

TABLE 3

BLAST Results for Sequences Encoding Polypeptides
Homologous to UDP-Galactose 4-Epimerase

Clone	Status	BLAST pLog Score	
		1173555	3021357
cen3n.pk0155.b8	EST	76.00	90.40
rlr2.pk0043.c3	EST	24.10	35.52
sls2c.pk017.k22	EST	66.52	40.40
wdk5c.pk006.o4	EST	68.70	40.40

The sequence of the entire cDNA insert in the clones mentioned above was determined. Further analyses of the data indicated that there are two forms of UDP-galactose 4-epimerase, a cytoplasmic form similar to the *Pisum sativum* sequence, and a plastid form similar to the *Cyamopsis tetragonoloba* sequence. ESTs encoding both kinds of UDP-galactose 4-epimerases were found in the DuPont proprietary database. The BLAST search using the sequences from clones listed in Table 4 revealed similarity of the polypeptides encoded by the cDNAs to UDP-galactose 4-epimerase (cytoplasmic) from *Pisum sativum* (NCBI General Identifier No. 1173555). Shown in Table 4 are the BLAST

results for individual ESTs ("EST"), or for the sequences of the entire cDNA inserts comprising the indicated cDNA clones and encoding the entire protein ("CGS"):

TABLE 4

5 BLAST Results for Sequences Encoding Polypeptides
Homologous to Cytoplasmic UDP-Galactose 4-Epimerase

Clone	Status	BLAST pLog Score 1173555
p0083.clddm72r	EST	84.30
rls24.pk0008.d12	EST	26.10
sls2c.pk017.k22:fis	CGS	>254.00
wdk5c.pk006.o4:fis	CGS	154.00

The BLAST search using the sequences from clones listed in Table 5 revealed similarity of the polypeptides encoded by the cDNAs to UDP-galactose 4-epimerase (plastid) from *Cyamopsis tetragonoloba* (NCBI General Identifier No. 3021357). Shown in
10 Table 5 are the BLAST results for individual ESTs ("EST"), the sequences of the entire cDNA inserts comprising the indicated cDNA clones ("FIS"), or FIS sequences encoding the entire protein ("CGS"):

TABLE 5

15 BLAST Results for Sequences Encoding Polypeptides
Homologous to Plastid UDP-Galactose 4-Epimerase

Clone	Status	BLAST pLog Score 3021357
cen3n.pk0155.b8:fis	FIS	138.00
rlr2.pk0043.c3:fis	CGS	165.00
se6.pk0014.f12	CGS	>254.00
wlm0.pk0015.g3	EST	21.00

Figure 1 presents an alignment of the amino acid sequences set forth in SEQ ID
20 NOs:14, 16, 18, and 22 and the *Pisum sativum* and *Cyamopsis tetragonoloba* sequences (SEQ ID NO:25 and SEQ ID NO:26). The amino acid sequence from clone cen3n.pk0155.b8:fis contains 353 amino acids and the amino acid sequence from *Cyamopsis tetragonoloba* contains 350 amino acids, but the alignment between both sequences starts at amino acid 65 of the *Cyamopsis tetragonoloba* sequence. The data in Table 6 represents a
25 calculation of the percent identity of the amino acid sequences set forth in SEQ ID NOs:2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, and 24 and the *Pisum sativum* and *Cyamopsis tetragonoloba* sequences (SEQ ID NO:25 and SEQ ID NO:26).

TABLE 6

Percent Identity of Amino Acid Sequences Deduced From the Nucleotide Sequences
Sequences of cDNA Clones Encoding Polypeptides
Homologous UDP-Galactose 4-Epimerases

SEQ ID NO.	Percent Identity to	
	1173555	3021357
2	66.3	77.5
4	52.5	67.7
6	79.1	53.4
8	66.0	54.9
10	56.3	53.3
12	47.5	44.4
14	90.0	64.9
16	71.1	62.6
18	56.3	64.3
20	64.3	78.9
22	63.3	87.1
24	29.1	45.6

5 Sequence alignments and percent identity calculations were performed using the Megalign program of the LASERGENE bioinformatics computing suite (DNASTAR Inc., Madison, WI). Multiple alignment of the sequences was performed using the Clustal method of alignment (Higgins and Sharp (1989) *CABIOS* 5:151-153) with the default parameters (GAP PENALTY=10, GAP LENGTH PENALTY=10). Default parameters for pairwise alignments using the Clustal method were KTUPLE 1, GAP PENALTY=3, WINDOW=5 and DIAGONALS SAVED=5. Sequence alignments and BLAST scores and probabilities indicate that the nucleic acid fragments comprising the instant cDNA clones encode a substantial portion or entire corn, rice, soybean, and wheat cytoplasmic UDP-galactose 4-epimerase and a substantial portion or entire corn, rice, soybean, and wheat plastidic UDP-galactose 4-epimerase. These sequences represent the first corn, rice, soybean, and wheat sequences encoding UDP-galactose 4-epimerase.

EXAMPLE 4

Expression of Chimeric Genes in Monocot Cells

20 A chimeric gene comprising a cDNA encoding the instant polypeptides in sense orientation with respect to the maize 27 kD zein promoter that is located 5' to the cDNA fragment, and the 10 kD zein 3' end that is located 3' to the cDNA fragment, can be constructed. The cDNA fragment of this gene may be generated by polymerase chain reaction (PCR) of the cDNA clone using appropriate oligonucleotide primers. Cloning sites (NcoI or SmaI) can be incorporated into the oligonucleotides to provide proper orientation

25

of the DNA fragment when inserted into the digested vector pML103 as described below. Amplification is then performed in a standard PCR. The amplified DNA is then digested with restriction enzymes NcoI and SmaI and fractionated on an agarose gel. The appropriate band can be isolated from the gel and combined with a 4.9 kb NcoI-SmaI fragment of the plasmid pML103. Plasmid pML103 has been deposited under the terms of the Budapest Treaty at ATCC (American Type Culture Collection, 10801 University Blvd., Manassas, VA 20110-2209), and bears accession number ATCC 97366. The DNA segment from pML103 contains a 1.05 kb Sall-NcoI promoter fragment of the maize 27 kD zein gene and a 0.96 kb SmaI-Sall fragment from the 3' end of the maize 10 kD zein gene in the vector pGem9Zf(+) (Promega). Vector and insert DNA can be ligated at 15°C overnight, essentially as described (Maniatis). The ligated DNA may then be used to transform *E. coli* XL1-Blue (Epicurian Coli XL-1 Blue™; Stratagene). Bacterial transformants can be screened by restriction enzyme digestion of plasmid DNA and limited nucleotide sequence analysis using the dideoxy chain termination method (Sequenase™ DNA Sequencing Kit; U.S. Biochemical). The resulting plasmid construct would comprise a chimeric gene encoding, in the 5' to 3' direction, the maize 27 kD zein promoter, a cDNA fragment encoding the instant polypeptides, and the 10 kD zein 3' region.

The chimeric gene described above can then be introduced into corn cells by the following procedure. Immature corn embryos can be dissected from developing caryopses derived from crosses of the inbred corn lines H99 and LH132. The embryos are isolated 10 to 11 days after pollination when they are 1.0 to 1.5 mm long. The embryos are then placed with the axis-side facing down and in contact with agarose-solidified N6 medium (Chu et al. (1975) *Sci. Sin. Peking* 18:659-668). The embryos are kept in the dark at 27°C. Friable embryogenic callus consisting of undifferentiated masses of cells with somatic proembryoids and embryoids borne on suspensor structures proliferates from the scutellum of these immature embryos. The embryogenic callus isolated from the primary explant can be cultured on N6 medium and sub-cultured on this medium every 2 to 3 weeks.

The plasmid, p35S/Ac (obtained from Dr. Peter Eckes, Hoechst Ag, Frankfurt, Germany) may be used in transformation experiments in order to provide for a selectable marker. This plasmid contains the *Pat* gene (see European Patent Publication 0 242 236) which encodes phosphinothricin acetyl transferase (PAT). The enzyme PAT confers resistance to herbicidal glutamine synthetase inhibitors such as phosphinothricin. The *pat* gene in p35S/Ac is under the control of the 35S promoter from Cauliflower Mosaic Virus (Odell et al. (1985) *Nature* 313:810-812) and the 3' region of the nopaline synthase gene from the T-DNA of the Ti plasmid of *Agrobacterium tumefaciens*.

The particle bombardment method (Klein et al. (1987) *Nature* 327:70-73) may be used to transfer genes to the callus culture cells. According to this method, gold particles (1 µm in diameter) are coated with DNA using the following technique. Ten µg of plasmid DNAs

are added to 50 μ L of a suspension of gold particles (60 mg per mL). Calcium chloride (50 μ L of a 2.5 M solution) and spermidine free base (20 μ L of a 1.0 M solution) are added to the particles. The suspension is vortexed during the addition of these solutions. After 10 minutes, the tubes are briefly centrifuged (5 sec at 15,000 rpm) and the supernatant removed. The particles are resuspended in 200 μ L of absolute ethanol, centrifuged again and the supernatant removed. The ethanol rinse is performed again and the particles resuspended in a final volume of 30 μ L of ethanol. An aliquot (5 μ L) of the DNA-coated gold particles can be placed in the center of a Kapton™ flying disc (Bio-Rad Labs). The particles are then accelerated into the corn tissue with a Biolistic™ PDS-1000/He (Bio-Rad Instruments, Hercules CA), using a helium pressure of 1000 psi, a gap distance of 0.5 cm and a flying distance of 1.0 cm.

For bombardment, the embryogenic tissue is placed on filter paper over agarose-solidified N6 medium. The tissue is arranged as a thin lawn and covered a circular area of about 5 cm in diameter. The petri dish containing the tissue can be placed in the chamber of the PDS-1000/He approximately 8 cm from the stopping screen. The air in the chamber is then evacuated to a vacuum of 28 inches of Hg. The macrocarrier is accelerated with a helium shock wave using a rupture membrane that bursts when the He pressure in the shock tube reaches 1000 psi.

Seven days after bombardment the tissue can be transferred to N6 medium that contains gluphosinate (2 mg per liter) and lacks casein or proline. The tissue continues to grow slowly on this medium. After an additional 2 weeks the tissue can be transferred to fresh N6 medium containing gluphosinate. After 6 weeks, areas of about 1 cm in diameter of actively growing callus can be identified on some of the plates containing the glufosinate-supplemented medium. These calli may continue to grow when sub-cultured on the selective medium.

Plants can be regenerated from the transgenic callus by first transferring clusters of tissue to N6 medium supplemented with 0.2 mg per liter of 2,4-D. After two weeks the tissue can be transferred to regeneration medium (Fromm et al. (1990) *Bio/Technology* 8:833-839).

EXAMPLE 5

Expression of Chimeric Genes in Dicot Cells

A seed-specific expression cassette composed of the promoter and transcription terminator from the gene encoding the β subunit of the seed storage protein phaseolin from the bean *Phaseolus vulgaris* (Doyle et al. (1986) *J. Biol. Chem.* 261:9228-9238) can be used for expression of the instant polypeptides in transformed soybean. The phaseolin cassette includes about 500 nucleotides upstream (5') from the translation initiation codon and about 1650 nucleotides downstream (3') from the translation stop codon of phaseolin. Between the 5' and 3' regions are the unique restriction endonuclease sites Nco I (which includes the ATG

translation initiation codon), Sma I, Kpn I and Xba I. The entire cassette is flanked by Hind III sites.

5 The cDNA fragment of this gene may be generated by polymerase chain reaction (PCR) of the cDNA clone using appropriate oligonucleotide primers. Cloning sites can be incorporated into the oligonucleotides to provide proper orientation of the DNA fragment when inserted into the expression vector. Amplification is then performed as described above, and the isolated fragment is inserted into a pUC18 vector carrying the seed expression cassette.

10 Soybean embryos may then be transformed with the expression vector comprising sequences encoding the instant polypeptides. To induce somatic embryos, cotyledons, 3-5 mm in length dissected from surface sterilized, immature seeds of the soybean cultivar A2872, can be cultured in the light or dark at 26°C on an appropriate agar medium for 6-10 weeks. Somatic embryos which produce secondary embryos are then excised and placed into a suitable liquid medium. After repeated selection for clusters of somatic
15 embryos which multiplied as early, globular staged embryos, the suspensions are maintained as described below.

Soybean embryogenic suspension cultures can maintained in 35 mL liquid media on a rotary shaker, 150 rpm, at 26°C with florescent lights on a 16:8 hour day/night schedule. Cultures are subcultured every two weeks by inoculating approximately 35 mg of tissue into
20 35 mL of liquid medium.

Soybean embryogenic suspension cultures may then be transformed by the method of particle gun bombardment (Klein et al. (1987) *Nature* (London) 327:70-73, U.S. Patent No. 4,945,050). A DuPont Biolistic™ PDS1000/HE instrument (helium retrofit) can be used for these transformations.

25 A selectable marker gene which can be used to facilitate soybean transformation is a chimeric gene composed of the 35S promoter from Cauliflower Mosaic Virus (Odell et al. (1985) *Nature* 313:810-812), the hygromycin phosphotransferase gene from plasmid pJR225 (from *E. coli*; Gritz et al.(1983) *Gene* 25:179-188) and the 3' region of the nopaline synthase gene from the T-DNA of the Ti plasmid of *Agrobacterium tumefaciens*. The seed expression
30 cassette comprising the phaseolin 5' region, the fragment encoding the instant polypeptides and the phaseolin 3' region can be isolated as a restriction fragment. This fragment can then be inserted into a unique restriction site of the vector carrying the marker gene.

To 50 µL of a 60 mg/mL 1 µm gold particle suspension is added (in order): 5 µL DNA (1 µg/µL), 20 µl spermidine (0.1 M), and 50 µL CaCl₂ (2.5 M). The particle
35 preparation is then agitated for three minutes, spun in a microfuge for 10 seconds and the supernatant removed. The DNA-coated particles are then washed once in 400 µL 70% ethanol and resuspended in 40 µL of anhydrous ethanol. The DNA/particle suspension can

be sonicated three times for one second each. Five μ L of the DNA-coated gold particles are then loaded on each macro carrier disk.

Approximately 300-400 mg of a two-week-old suspension culture is placed in an empty 60x15 mm petri dish and the residual liquid removed from the tissue with a pipette.

5 For each transformation experiment, approximately 5-10 plates of tissue are normally bombarded. Membrane rupture pressure is set at 1100 psi and the chamber is evacuated to a vacuum of 28 inches mercury. The tissue is placed approximately 3.5 inches away from the retaining screen and bombarded three times. Following bombardment, the tissue can be divided in half and placed back into liquid and cultured as described above.

10 Five to seven days post bombardment, the liquid media may be exchanged with fresh media, and eleven to twelve days post bombardment with fresh media containing 50 mg/mL hygromycin. This selective media can be refreshed weekly. Seven to eight weeks post bombardment, green, transformed tissue may be observed growing from untransformed, necrotic embryogenic clusters. Isolated green tissue is removed and inoculated into
15 individual flasks to generate new, clonally propagated, transformed embryogenic suspension cultures. Each new line may be treated as an independent transformation event. These suspensions can then be subcultured and maintained as clusters of immature embryos or regenerated into whole plants by maturation and germination of individual somatic embryos.

EXAMPLE 6

Expression of Chimeric Genes in Microbial Cells

20 The cDNAs encoding the instant polypeptides can be inserted into the T7 *E. coli* expression vector pBT430. This vector is a derivative of pET-3a (Rosenberg et al. (1987) *Gene* 56:125-135) which employs the bacteriophage T7 RNA polymerase/T7 promoter system. Plasmid pBT430 was constructed by first destroying the EcoR I and Hind III sites in
25 pET-3a at their original positions. An oligonucleotide adaptor containing EcoR I and Hind III sites was inserted at the BamH I site of pET-3a. This created pET-3aM with additional unique cloning sites for insertion of genes into the expression vector. Then, the Nde I site at the position of translation initiation was converted to an Nco I site using oligonucleotide-directed mutagenesis. The DNA sequence of pET-3aM in this region,
30 5'-CATATGG, was converted to 5'-CCCATGG in pBT430.

Plasmid DNA containing a cDNA may be appropriately digested to release a nucleic acid fragment encoding the protein. This fragment may then be purified on a 1% NuSieve GTG™ low melting agarose gel (FMC). Buffer and agarose contain 10 μ g/ml ethidium bromide for visualization of the DNA fragment. The fragment can then be purified from the
35 agarose gel by digestion with GELase™ (Epicentre Technologies) according to the manufacturer's instructions, ethanol precipitated, dried and resuspended in 20 μ L of water. Appropriate oligonucleotide adapters may be ligated to the fragment using T4 DNA ligase (New England Biolabs, Beverly, MA). The fragment containing the ligated adapters can be

purified from the excess adapters using low melting agarose as described above. The vector pBT430 is digested, dephosphorylated with alkaline phosphatase (NEB) and deproteinized with phenol/chloroform as described above. The prepared vector pBT430 and fragment can then be ligated at 16°C for 15 hours followed by transformation into DH5 electrocompetent cells (GIBCO BRL). Transformants can be selected on agar plates containing LB media and 100 µg/mL ampicillin. Transformants containing the gene encoding the instant polypeptides are then screened for the correct orientation with respect to the T7 promoter by restriction enzyme analysis.

For high level expression, a plasmid clone with the cDNA insert in the correct orientation relative to the T7 promoter can be transformed into *E. coli* strain BL21(DE3) (Studier et al. (1986) *J. Mol. Biol.* 189:113-130). Cultures are grown in LB medium containing ampicillin (100 mg/L) at 25°C. At an optical density at 600 nm of approximately 1, IPTG (isopropylthio-β-galactoside, the inducer) can be added to a final concentration of 0.4 mM and incubation can be continued for 3 h at 25°. Cells are then harvested by centrifugation and re-suspended in 50 µL of 50 mM Tris-HCl at pH 8.0 containing 0.1 mM DTT and 0.2 mM phenyl methylsulfonyl fluoride. A small amount of 1 mm glass beads can be added and the mixture sonicated 3 times for about 5 seconds each time with a microprobe sonicator. The mixture is centrifuged and the protein concentration of the supernatant determined. One µg of protein from the soluble fraction of the culture can be separated by SDS-polyacrylamide gel electrophoresis. Gels can be observed for protein bands migrating at the expected molecular weight.

EXAMPLE 7

Functional Expression of the Soybean UDP-Galactose 4-Epimerase in *E. coli*

Soybean varieties with inherently reduced raffinose saccharide content would improve the nutritional quality of derived soy protein products and reduce processing costs associated with the removal of raffinose saccharides. Said low raffinose saccharide soybean varieties would be more valuable than conventional varieties for animal and human diets and would allow mankind to more fully utilize the desirable nutritional qualities of this edible legume.

Soybean clone sls2c.pk017.k22: fis (SEQ ID NO:14), encoding an almost entire UDP-galactose 4-epimerase, was cloned into a pET24d vector and transformed into DH5α competent cells to determine its activity in microbial cells. The fragment encoding the soybean UDP-galactose 4-epimerase was released from the BS-SK vector using restriction enzymes Eco RI and Sma I which are located in the multiple cloning site of the vector. To obtain a blunt end, the Eco RI restriction site was filled-in using T4 DNA polymerase (New England Biolabs). Nco I adapters (SEQ ID NO:27 and SEQ ID NO:28) containing a start methionine and three additional amino acids were ligated overnight at 16°C to the blunt-ended UDP-galactose 4-epimerase fragment.

(SEQ ID NO:27) CATGGAGGAGCAG

CTCCTCGTC

(SEQ ID NO:28)

After heat-inactivation of the ligase, adapter ends were phosphorylated with T4 polynucleotide kinase (New England Biolabs) for 30 minutes at 37°C. The 1255 bp UDP-galactose 4-epimerase fragment was gel purified using a 1% low melting agarose gel following manufacturers directions (FMC). The purified UDP-galactose 4-epimerase fragment containing phosphorylated Nco I adapter ends was ligated into an Nco I restricted pET24d vector (Novagen) overnight at 16°C. The ligation was transformed into DH5 α competent cells and plated onto 2xYT/50 μ g/ml kanamycin plates. Plasmid DNA was purified and screened for insert and orientation by restriction with Eco RI. A clone in the sense orientation with respect to the T7 promoter and a clone with the insert in the antisense orientation with respect to the T7 promoter (negative control) were transformed into BL21(DE3) competent cells (Novagen).

Single colonies were grown overnight at 37°C in 2x YT medium containing 50 μ g/ml kanamycin. The cultures were diluted 30 fold in fresh medium and allowed to grow for an additional 2 hours to an optical density (at 600 nm) of 1.0. Expression of the cDNA insert was induced by addition of isopropyl β -D-thiogalactopyranoside (IPTG) to the cultures to a final concentration of 1 mM. Cells were harvested by centrifugation after 3 hours and resuspended in 100 μ l of 100 mM potassium phosphate at pH 7.0 containing 3 mM dithiothreitol (DTT) and 4 mM phenylmethylsulfonylfluoride. A small amount of 1 mm glass beads were added and the mixture was sonicated three times for about 5 seconds each time with a microprobe sonicator. The mixture was centrifuged and the supernatant containing the protein transferred to a fresh tube.

For assay of UDP 4-epimerase activity the following components were prepared in 100 mM phosphate buffer, pH 7.0: 20 mM NADP, 200 mM sodium pyrophosphate, 1 mM glucose 1,6 diphosphate, 0.5 mM DTTI, 1 unit/ μ l phosphoglucomutase, 1 unit/ μ l glucose 6-phosphate dehydrogenase, 0.05 units/ μ l UDP-glucose pyrophosphorylase, 100 mM UDP-galactose and 0.04 units/ μ l UDP-galactose 4-epimerase (SIGMA). Each 269 μ l assay contained 180 μ l potassium phosphate buffer, 25 μ l NADP, 5 μ l sodium pyrophosphate, 25 μ l glucose 1,6 diphosphate, 1 μ l DTT, 8 μ l phosphoglucomutase, 1 μ l glucose 6-pyrophosphorylase, and 20 μ l cell extract (or UDP-galactose 4-epimerase). The reaction was initiated with the addition of 2 μ l 100 mM UDP-galactose and the production of NADPH was followed by monitoring the absorbance at 340 nm using a Shimadzu UV160U spectrophotometer. A nine-fold increase in epimerase activity was observed in the vessels containing the soybean UDP-galactose 4-epimerase fragment in the sense orientation with respect to the T7 promoter over those containing the soybean UDP-galactose 4-epimerase fragment in the antisense orientation with respect to the T7 promoter. As expected, an

approximately 37 kDa-expressed protein was observed in the soluble fraction of the induced DE3 cells containing the sense construct of pET24d-epimerase 4a.

EXAMPLE 8

Functional Expression of the Soybean UDP-Galactose

5 4-Epimerase in Soybean Somatic Embryos

The ability to change the levels of the raffinose pathway by overexpressing the gene from soybean clone sls2c.pk017.k22: fis in soybean somatic embryos was tested by preparing transgenic soybean somatic embryos and assaying the raffinose, stachyose, and sucrose levels. A cosuppressed phenotype should have low to nondetectable levels of
10 raffinose and stachyose and increased levels of sucrose and can be expressed as a ratio of sucrose/(raffinose + stachyose). A ratio of less than 1 is considered a wild type phenotype, while a ratio of greater than 2.0 is considered a cosuppressed event.

The entire insert from clone sls2c.pk017.k22: fis was amplified in a standard PCR reaction on a Perkin Elmer Applied Biosystems GeneAmp PCR System using Pfu
15 polymerase (Stratagene). The resulting fragment is bound by an Nco I site at the 5' end and by a Pst I fragment at the 3' end. This fragment was digested, isolated, and ligated into the Nco I/Pst I sites of plasmid pKS18HH (described in US Patent No. 5,846,784) which had been modified by the insertion of the soybean glycinin subunit G1 promoter and terminator signals at the Sac I site. The sequence of the soybean Gyl glycinin subunit G1 was
20 published by Sims and Goldberg (1989, Nucl. Acids Res. 17:4386). The promoter sequence consists of nucleotides 1 through 690 and the terminator sequence consists of nucleotides 3126 through 3527. The new plasmid was named G1-epimerase and contains the Gyl promoter, the epimerase sequence, and the Gyl termination signal surrounded by Sac I sites in plasmid pKS18HH.

25 *Transformation of Soybean Somatic Embryo Cultures*

The following stock solutions and media were used for transformation and propagation of soybean somatic embryos:

<u>Stock Solutions</u>		<u>Media</u>
<u>MS Sulfate 100x stock</u>	<u>(g/L)</u>	<u>SB55 (per Liter)</u>
MgSO ₄ ·7H ₂ O	37.0	10 mL of each MS stock
MnSO ₄ ·H ₂ O	1.69	1 mL of B5 Vitamin stock
ZnSO ₄ ·7H ₂ O	0.86	0.8 g NH ₄ NO ₃
CuSO ₄ ·5H ₂ O	0.0025	3.033 g KNO ₃
		1 mL 2,4-D (10 mg/mL stock)
<u>MS Halides 100x stock</u>		0.667 g asparagine
CaCl ₂ ·2H ₂ O	44.0	pH 5.7
KI	0.083	

CoCl ₂ .6H ₂ O	0.00125	<u>SB103 (per Liter)</u>
KH ₂ PO ₄	17.0	1 pk. Murashige & Skoog salt mixture*
H ₃ BO ₃	0.62	60 g maltose
Na ₂ MoO ₄ .2H ₂ O	0.025	2 g gelrite
Na ₂ EDTA	3.724	pH 5.7
FeSO ₄ .7H ₂ O	2.784	
		<u>SB148 (per Liter)</u>
<u>B5 Vitamin stock</u>		1 pk. Murashige & Skoog salt mixture*
<i>myo</i> -inositol	100.0	60 g maltose
nicotinic acid	1.0	1 mL B5 vitamin stock
pyridoxine HCl	1.0	7 g agarose
thiamine	10.0	pH 5.7
		*(Gibco BRL)

Soybean embryonic suspension cultures were maintained in 35 mL liquid media (SB55) on a rotary shaker (150 rpm) at 28°C with a mix of fluorescent and incandescent lights providing a 16 h day 8 h night cycle. Cultures were subcultured every 2 to 3 weeks by inoculating approximately 35 mg of tissue into 35 mL of fresh liquid media.

Soybean embryonic suspension cultures were transformed with G1-epimerase by the method of particle gun bombardment (see Klein et al. (1987) *Nature* 327:70-73) using a DuPont Biolistic PDS1000/He instrument. Five µL of G1-epimerase plasmid DNA (1 g/L), 50 µL CaCl₂ (2.5 M), and 20 µL spermidine (0.1 M) were added to 50 µL of a 60 mg/mL 1 mm gold particle suspension. The particle preparation was agitated for 3 minutes, spun in a microfuge for 10 seconds and the supernate removed. The DNA-coated particles were then washed once with 400 µL of 70% ethanol and resuspended in 40 µL of anhydrous ethanol. The DNA/particle suspension was sonicated three times for 1 second each. Five µL of the DNA-coated gold particles were then loaded on each macro carrier disk.

Approximately 300 to 400 mg of two-week-old suspension culture was placed in an empty 60 mm X 15 mm petri dish and the residual liquid removed from the tissue using a pipette. The tissue was placed about 3.5 inches away from the retaining screen and bombarded twice. Membrane rupture pressure was set at 1100 psi and the chamber was evacuated to -28 inches of Hg. Two plates were bombarded, and following bombardment, the tissue was divided in half, placed back into liquid media, and cultured as described above.

Fifteen days after bombardment, the liquid media was exchanged with fresh SB55 containing 50 mg/mL hygromycin. The selective media was refreshed weekly. Six weeks

after bombardment, green, transformed tissue was isolated and inoculated into flasks to generate new transformed embryonic suspension cultures.

Transformed embryonic clusters were removed from liquid culture media and placed on a solid agar media, SB103, containing 0.5% charcoal to begin maturation. After 1 week, embryos were transferred to SB103 media minus charcoal. After 5 weeks on SB103 media, maturing embryos were separated and placed onto SB148 media. During maturation embryos were kept at 26°C with a mix of fluorescent and incandescent lights providing a 16 h day 8 h night cycle. To mimic seed dry down, embryos were harvested after 5 weeks on SB148 media. Each embryonic cluster gave rise to 5 to 20 somatic embryos.

Non-transformed somatic embryos were cultured by the same method as used for the transformed somatic embryos.

Analysis of Transformed Somatic Embryos

At the end of the 5th week on SB148 medium somatic embryos were harvested from 14 independently transformed lines. Soluble carbohydrates were extracted by crushing the embryos with a nylon pestle in a microfuge tube containing 200 µL of 80% methanol. Extraction was repeated with an additional 200 µL of 80% methanol and the supernatants combined and dried. The soluble carbohydrates were resuspended in 200 µL water and analyzed using a Dionex DX500 chromatography system. Carbohydrates were separated on a Dionex CarboPac PAI (4x250 mm) column using 95% 0.2 M NaOH, 5% water at 1.0 ml/min. A total of 14 events (10 embryos each) were analyzed. The total area for the sugars raffinose, stachyose and sucrose were tabulated for each embryo. A cosuppressed phenotype should have low to nondetectable levels of raffinose and stachyose and increased levels of sucrose and can be expressed as a ratio of sucrose/(raffinose + stachyose). A ratio of less than 1.0 is considered a wildtype phenotype, while a ratio of greater than 2.0 is considered a cosuppressed event. The averages and standard deviations for the areas of sucrose, raffinose, stachyose, and the ratio of sucrose/(raffinose + stachyose) for each of the 14 samples are indicated in Table 7:

TABLE 7

Averages and Standard Deviations of the Carbohydrates From
Somatic Soybean Embryos Expressing Chimeric
Soybean UDP-Galactose 4-Epimerases

Somatic Embryo	Sucrose	Raffinose	Stachyose	Sucrose/ (Raffinose+Stachyose)
4/4	3568973.7 ±1408264.7	1045112.8 ±641756.9	3967517 ±2900645.5	1.02±0.8
4/5	2856327.7 ±707852.7	904544 ±521259.0	3557979.3 ±1715496.3	0.88±0.7
4/7	2877070.1 ±873920.3	717643.3 ±609431.0	3009836.7 ±2407257.1	1±0.4

Somatic Embryo	Sucrose	Raffinose	Stachyose	Sucrose/ (Raffinose+Stachyose)
4/1	2653179.9 ±1046953.1	709370 ±379902.4	3876536.5 ±1999692.2	0.77±0.5
4/2	2857092.7 ±742415.0	626307.5 ±115743.8	3121925.9 ±951294.5	0.76±0.08
4/6	3112203.2 ±850601.7	754341.9 ±262408.2	4601053 ±1461924.7	0.61±0.15
4/3	3282564.1 ±1911513.1	706353.5 ±428861.1	4602803.6 ±2261654.1	0.58±0.17
3/3	2691493.3 ±1538378.2	536062.6 ±231855.5	2838255.8 ±1048200.9	0.77±0.32
3/1	2283160.5 ±1089482.4	449773.1 ±229549.7	1983356 ±1099495.3	1.44±1.25
3/4	3375314.6 ±805313.2	616473.8 ±185309.4	3940545.5 ±845544.6	0.76±0.19
3/6	81106208.1 ±30013245.6	17813664.4 ±9546497.2	101268706.9 ±50277358.9	0.72±0.14
3/2	89847214.2 ±14908804.2	17040544.3 ±5550687.9	88496699.5 ±34107697.8	1.05±0.70
3/1(repeat)	73558780.2 ±35218563.3	17948085.3 ±14008680.2	73769338.2 ±49942666.1	1.46±1.51
3/5	68427093.9 ±20712691.0	13192646.4 ±9066329.2	55486977 ±36156784.6	1.24±0.75

Of the 14 events analyzed, two were considered cosuppressed for UDP-glucose 4'epimerase (4/1 and 3/1). Both of these events have at least 2 embryos that have a ratio greater than 2.0. Event 3/1 was repeated and both times exhibited cosuppression.

Various modifications of the invention in addition to those shown and described herein will be apparent to those skilled in the art from the foregoing description. Such modifications are also intended to fall within the scope of the appended claims.

The disclosure of each reference set forth above is incorporated herein by reference in its entirety.

CLAIMS

What is claimed is:

1. An isolated polynucleotide comprising a first nucleotide sequence encoding a polypeptide of at least 90 amino acids that has at least 95% identity based on the Clustal method of alignment when compared to a polypeptide selected from the group consisting of SEQ ID NOs:2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, and 24,
or a second nucleotide sequence comprising the complement of the first nucleotide sequence.
2. The isolated polynucleotide of Claim 1, wherein the first nucleotide sequence consists of a nucleic acid sequence selected from the group consisting of SEQ ID NOs:1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, and 23 that codes for the polypeptide selected from the group consisting of SEQ ID NOs:2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, and 24.
3. The isolated polynucleotide of Claim 1 wherein the nucleotide sequences are DNA.
4. The isolated polynucleotide of Claim 1 wherein the nucleotide sequences are RNA.
5. A chimeric gene comprising the isolated polynucleotide of Claim 1 operably linked to suitable regulatory sequences.
6. A host cell comprising the chimeric gene of Claim 5.
7. A host cell comprising an isolated polynucleotide of Claim 1.
8. The host cell of Claim 7 wherein the host cell is selected from the group consisting of yeast, bacteria, plant, and virus.
9. A virus comprising the isolated polynucleotide of Claim 1.
10. A polypeptide of at least 90 amino acids that has at least 95% identity based on the Clustal method of alignment when compared to a polypeptide selected from the group consisting of SEQ ID NOs:2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, and 24.
11. A method of selecting an isolated polynucleotide that affects the level of expression of a UDP-galactose 4-epimerase polypeptide in a plant cell, the method comprising the steps of:
 - (a) constructing an isolated polynucleotide comprising a nucleotide sequence of at least one of 30 contiguous nucleotides derived from an isolated polynucleotide of Claim 1;
 - (b) introducing the isolated polynucleotide into a plant cell;
 - (c) measuring the level of a polypeptide in the plant cell containing the polynucleotide; and
 - (d) comparing the level of polypeptide in the plant cell containing the isolated polynucleotide with the level of polypeptide in a plant cell that does not contain the isolated polynucleotide.

12. The method of Claim 11 wherein the isolated polynucleotide consists of a nucleotide sequence selected from the group consisting of SEQ ID NOs:1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, and 23 that codes for the polypeptide selected from the group consisting of SEQ ID NOs:2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, and 24.

5 13. A method of selecting an isolated polynucleotide that affects the level of expression of a UDP-galactose 4-epimerase polypeptide in a plant cell, the method comprising the steps of:

- (a) constructing an isolated polynucleotide of Claim 1;
- (b) introducing the isolated polynucleotide into a plant cell;
- 10 (c) measuring the level of polypeptide in the plant cell containing the polynucleotide; and
- (d) comparing the level of polypeptide in the plant cell containing the isolated polynucleotide with the level of polypeptide in a plant cell that does not contain the polynucleotide.

15 14. A method of obtaining a nucleic acid fragment encoding a UDP-galactose 4-epimerase polypeptide comprising the steps of:

- (a) synthesizing an oligonucleotide primer comprising a nucleotide sequence of at least one of 30 contiguous nucleotides derived from a nucleotide sequence selected from the group consisting of SEQ ID NOs:1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, and the
- 20 complement of such nucleotide sequences; and
- (b) amplifying a nucleic acid sequence using the oligonucleotide primer.

15 15. A method of obtaining a nucleic acid fragment encoding a UDP-galactose 4-epimerase polypeptide comprising the steps of:

- (a) probing a cDNA or genomic library with an isolated polynucleotide
- 25 comprising at least one of 30 contiguous nucleotides derived from a nucleotide sequence selected from the group consisting of SEQ ID NOs:1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, and the complement of such nucleotide sequences;
- (b) identifying a DNA clone that hybridizes with the isolated polynucleotide;
- (c) isolating the identified DNA clone; and
- 30 (d) sequencing the cDNA or genomic fragment that comprises the isolated DNA clone.

16. A composition comprising the isolated polynucleotide of Claim 1.

17. A composition comprising the isolated polynucleotide of Claim 10.

35 18. An isolated polynucleotide comprising the nucleotide sequence having at least one of 30 contiguous nucleotides derived from a nucleic acid sequence selected from the group consisting of SEQ ID NOs:1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, and the complement of such sequences.

19. An expression cassette comprising an isolated polynucleotide of Claim 1 operably linked to a promoter.

20. A method for positive selection of a transformed cell comprising:

5 (a) transforming a host cell with the chimeric gene of Claim 5 or an expression cassette of Claim 20; and

(b) growing the transformed host cell under conditions which allow expression of the polynucleotide in an amount sufficient to complement a null mutant to provide a positive selection means.

21. The method of Claim 20 wherein the plant cell is a monocot.

10 22. The method of Claim 20 wherein the plant cell is a dicot.

[illegible]

JG65 REGD POLICE J C AUG 2007

09/913064

Figure 1

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SEQ ID NO:14 IILLRYFNPVGAHESGKLGEDPKGIPNNLMPYIQQVAVGRLTELNVYGHDPYTRDGSAIR *
SEQ ID NO:16 TILLRYFNPIGAHESGDIIGEDPKGVPNNLLPYIQQVAVARRPELNVYGHDPYTRDGTAVR *
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JC95 Rec'd PCT/PTO 0 8 AUG 2007

Figure 1

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09/913064

SEQUENCE LISTING

JC05 Rec'd PCT/PTO 0 8 AUG 2001

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tggagaaggg ctacgccgtc accgccgtcg acaacttcca caactccgtc cccgaggcgc 120
tcgaccgcgt ccgccacatc gtcggccccg ccctctccgc ccgctccaa ttcatcttcg 180
gggacctgac gatcaaggat gacctggaga aggtcttcgc cgccaagaag tacgacgccg 240
tgatacactt cgccgggctc aaggcgggtg cggagagcgt ggcgcacccg gagatgtaca 300
accgcaacaa catcgtcggc accgtcaacc tctacgacgt catgaagaag cacgggtgca 360
acaagttggt gttctcgtcg tcggcgaccg tgtacggcca gccggagaag gtgccctgct 420
tcgaggactc cccctcaag gccctcaacc cgtacggcag gaccaagctg tactggagga 480
gatctgcgcg actaccanca cgccgaancc gngtggngg 520

<210> 8
<211> 162
<212> PRT
<213> Triticum aestivum

<400> 8
 Val Leu Val Thr Gly Gly Ala Gly Phe Ile Gly Thr His Thr Val Leu
 1 5 10 15
 Gln Leu Leu Glu Lys Gly Tyr Ala Val Thr Ala Val Asp Asn Phe His
 20 25 30
 Asn Ser Val Pro Glu Ala Leu Asp Arg Val Arg His Ile Val Gly Pro
 35 40 45
 Ala Leu Ser Ala Arg Leu Gln Phe Ile Phe Gly Asp Leu Thr Ile Lys
 50 55 60
 Asp Asp Leu Glu Lys Val Phe Ala Ala Lys Lys Tyr Asp Ala Val Ile
 65 70 75 80
 His Phe Ala Gly Leu Lys Ala Val Ala Glu Ser Val Ala His Pro Glu
 85 90 95
 Met Tyr Asn Arg Asn Asn Ile Val Gly Thr Val Asn Leu Tyr Asp Val
 100 105 110
 Met Lys Lys His Gly Cys Asn Lys Leu Val Phe Ser Ser Ser Ala Thr
 115 120 125
 Val Tyr Gly Gln Pro Glu Lys Val Pro Cys Phe Glu Asp Ser Pro Leu
 130 135 140
 Lys Ala Leu Asn Pro Tyr Gly Arg Thr Lys Leu Tyr Trp Arg Arg Ser
 145 150 155 160
 Ala Arg

<210> 9
 <211> 594
 <212> DNA
 <213> Zea mays

<220>
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 cggctgcaag aagctgggtt tctcgtcatc cgccaccgtg tacggctggc cggaggtgat 180
 cccatgcgtc gaggactcca agctgcaggc cgccaaccca tacggcagga ccaagcttat 240
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 gcgctacttc aaccccatcg gtgcgcacag ctccggcgan atcgnagag gaccccaagg 360
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 tcaacgtcta cgggncacga ttacccacc cggggacggn acccgatca gggactacat 480
 acacgtcgtc gaactcgccg atgggcacat cgcaagggtc cangaaatct ncgactctcc 540
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<210> 10
 <211> 197
 <212> PRT
 <213> Zea mays

<220>
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 <222> (113)

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 <222> (115)

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<221> UNSURE

<222> (196)..(197)

<400> 10

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 1 5 10 15

Ala His Pro Glu Met Tyr Tyr Glu Asn Asn Leu Ile Gly Thr Ile Asn
 20 25 30

Leu Tyr Lys Ser Met Lys Glu His Gly Cys Lys Lys Leu Val Phe Ser
 35 40 45

Ser Ser Ala Thr Val Tyr Gly Trp Pro Glu Val Ile Pro Cys Val Glu
 50 55 60

Asp Ser Lys Leu Gln Ala Ala Asn Pro Tyr Gly Arg Thr Lys Leu Ile
 65 70 75 80

Leu Glu Asp Met Ala Arg Asp Tyr His Arg Ala Asp Thr Glu Trp Ser
 85 90 95

Ile Val Leu Leu Arg Tyr Phe Asn Pro Ile Gly Ala His Ser Ser Gly
 100 105 110

Xaa Ile Xaa Arg Gly Pro Gln Gly Asp Thr Glu Gln Pro Ala Ala Leu
 115 120 125

His Pro Ala Gly Xaa Arg Arg Xaa Ala Pro Arg Ala Gln Arg Leu Arg
 130 135 140

Xaa Thr Ile Thr Pro Pro Gly Asp Gly Thr Ala Ile Arg Asp Tyr Ile
 145 150 155 160

His Val Val Glu Leu Ala Asp Gly His Ile Ala Arg Ala Xaa Glu Leu
 165 170 175

Xaa Asp Ser Pro Asp Ile Ser Cys Val Gly Tyr Asn Leu Gly Val Gln
 180 185 190

Gly Arg Arg Xaa Xaa
 195

<210> 11

<211> 300

<212> DNA

<213> Oryza sativa

<220>
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acgaggacaa cgtcgccggc accatgaacc tctnctccgc cttgaccaag tacggcngcn 180
agangatagt gttctcgctg tnggcgacng tgtncggcca gccgganaag accccctgcg 240
tcgaggnttc cnagctgagc gctctcaacc catacggcgc cancnggctc gtctctggaga 300

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<210> 12
<211> 99
<212> PRT
<213> Oryza sativa

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<220>
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<222> (6)

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<220>
<221> UNSURE
<222> (28)

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<220>
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<222> (51)

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<220>
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<222> (59)..(60)..(61)

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<220>
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<222> (67)

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<220>
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<222> (71)

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<220>
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<222> (75)

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<220>
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<222> (82)

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<220>
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<222> (84)

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<220>
<221> UNSURE
<222> (94)..(95)

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<400> 12
Asp Leu Lys Asp Arg Xaa Asn Trp Asn Lys Cys Tyr Ala Ala Lys Arg
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Tyr Asp Ala Val Ile His Phe Ala Gly Leu Lys Xaa Trp Gly Arg Ala
          20             25             30

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Ser Arg Asn Pro Gln Met Tyr Tyr Glu Asp Asn Val Ala Gly Thr Met
 35 40 45

Asn Leu Xaa Ser Ala Leu Thr Lys Tyr Gly Xaa Xaa Xaa Ile Val Phe
 50 55 60

Ser Ser Xaa Ala Thr Val Xaa Gly Gln Pro Xaa Lys Thr Pro Cys Val
 65 70 75 80

Glu Xaa Ser Xaa Leu Ser Ala Leu Asn Pro Tyr Gly Ala Xaa Xaa Leu
 85 90 95

Val Leu Glu

<210> 13
 <211> 1312
 <212> DNA
 <213> Glycine max

<400> 13

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gtcacgggtg	gtgccggttt	cattggcacc	cacaccgtcg	ttcagcttct	caaagctggc	120
ttcagcggtt	caataatcga	caatttcgat	aactccgtca	tggaagcagt	ggaccgcgtc	180
cgccaagtgg	ttggccctct	gctttctcag	aacctccaat	tcaccaggg	cgatctccgg	240
aatagggatg	acttgagaaa	actcttctcc	aaaacaacat	ttgatgccgt	gatccacttt	300
gctggcttga	aagcgggttg	tgaaagcggt	gcgaagcccc	gtcgctattt	tgattttaat	360
ttggttggca	ccatcaacct	ctacgagttt	atggcaaagt	ataattgcaa	aaagatggtt	420
ttctcatcat	ctgcaaccgt	ttatggccaa	cctgaaaaga	taccgtgtga	ggaggatttc	480
aagttacaag	ctatgaatcc	ctatggacgg	accaagcttt	tcctggaaga	aattgcccga	540
gatattcaga	aagctgaacc	agaatggaag	atcatattac	tgagatactt	caatccagtt	600
ggggctcatg	aaagtggcaa	actcggtgaa	gatcccaagg	gcatcccaaa	taacctcatg	660
ccttacattc	agcaagtagc	tggttgaaga	tgactgaac	tcaatgtata	cggtcatgat	720
tatccaacga	gggatggctc	tgcatccgg	gactatatcc	atgtgatgga	cttggcagat	780
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aacctgggaa	ctggctcgtg	aacatctgtg	cttgaaatgg	ttacagcatt	tgaaaaggct	900
tctggcaaga	aaattccagt	aaaattatgt	ccaagaagac	cgggagatgc	gactgaggtt	960
tatgcatcta	cagagagagc	tgagaaaaga	cttggttggg	aggcaaaacta	tggtgtggag	1020
gagatgtgca	gggaccaatg	gaattgggca	aagaacaatc	cctgggggtta	cgcggggaag	1080
ccttgaaatta	gcttgagaaa	tatactgctc	atctacgaat	gcttttcaca	taaataaggca	1140
tctcttatat	agaatacttt	tatgtttgat	gatttggtta	ggcagttcgt	tgtataatct	1200
tgacaataaaa	aatttggcag	catttcaaga	agttaaagct	atgtatttaa	acaataactt	1260
taaattagac	tggccattga	tttgatattg	aaaaaaaaaa	aaaaaaaaaa	aa	1312

<210> 14
 <211> 350
 <212> PRT
 <213> Glycine max

<400> 14

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			20					25					30		
Ser	Ile	Ile	Asp	Asn	Phe	Asp	Asn	Ser	Val	Met	Glu	Ala	Val	Asp	Arg
	35						40					45			

Val Arg Gln Val Val Gly Pro Leu Leu Ser Gln Asn Leu Gln Phe Thr
 50 55 60
 Gln Gly Asp Leu Arg Asn Arg Asp Asp Leu Glu Lys Leu Phe Ser Lys
 65 70 75 80
 Thr Thr Phe Asp Ala Val Ile His Phe Ala Gly Leu Lys Ala Val Ala
 85 90 95
 Glu Ser Val Ala Lys Pro Arg Arg Tyr Phe Asp Phe Asn Leu Val Gly
 100 105 110
 Thr Ile Asn Leu Tyr Glu Phe Met Ala Lys Tyr Asn Cys Lys Lys Met
 115 120 125
 Val Phe Ser Ser Ser Ala Thr Val Tyr Gly Gln Pro Glu Lys Ile Pro
 130 135 140
 Cys Glu Glu Asp Phe Lys Leu Gln Ala Met Asn Pro Tyr Gly Arg Thr
 145 150 155 160
 Lys Leu Phe Leu Glu Glu Ile Ala Arg Asp Ile Gln Lys Ala Glu Pro
 165 170 175
 Glu Trp Lys Ile Ile Leu Leu Arg Tyr Phe Asn Pro Val Gly Ala His
 180 185 190
 Glu Ser Gly Lys Leu Gly Glu Asp Pro Lys Gly Ile Pro Asn Asn Leu
 195 200 205
 Met Pro Tyr Ile Gln Gln Val Ala Val Gly Arg Leu Thr Glu Leu Asn
 210 215 220
 Val Tyr Gly His Asp Tyr Pro Thr Arg Asp Gly Ser Ala Ile Arg Asp
 225 230 235 240
 Tyr Ile His Val Met Asp Leu Ala Asp Gly His Ile Ala Ala Leu Arg
 245 250 255
 Lys Leu Phe Thr Thr Glu Asn Ile Gly Cys Thr Ala Tyr Asn Leu Gly
 260 265 270
 Thr Gly Arg Gly Thr Ser Val Leu Glu Met Val Thr Ala Phe Glu Lys
 275 280 285
 Ala Ser Gly Lys Lys Ile Pro Val Lys Leu Cys Pro Arg Arg Pro Gly
 290 295 300
 Asp Ala Thr Glu Val Tyr Ala Ser Thr Glu Arg Ala Glu Lys Glu Leu
 305 310 315 320
 Gly Trp Lys Ala Asn Tyr Gly Val Glu Glu Met Cys Arg Asp Gln Trp
 325 330 335
 Asn Trp Ala Lys Asn Asn Pro Trp Gly Tyr Ala Gly Lys Pro
 340 345 350

<210> 15
 <211> 1516



<212> DNA
 <213> *Triticum aestivum*

<220>
 <221> unsure
 <222> (1458)..(1459)

<400> 15
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 gacgccgtga tacacttcgc cgggctcaag gcggtggcgg agagcgtggc gcacccggag 300
 atgtacaacc gcaacaacat cgtcggcacc gtcaacctct acgacgtcat gaagaagcac 360
 ggggtgcaaca agttggtgtt ctgctcgtcg gcgaccgtgt acggccagcc ggagaagggtg 420
 ccctgcttcg aggactcccc cctcaaggcc ctcaaccctg acggcaggac caagctgtac 480
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 cgctacttca accccatcgg cgcacacgag agcggcgaca tcggggagga cccaaggggc 600
 gtccccaaca acctgtctcc ctacatccag caggtggccg tcgcccggcg ccccgagctc 660
 aacgtctacg gccacgacta ccgcaccgcg gacggcaccg ccgtcaggga ctacatccac 720
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 atcggtctgt tggcgtacaa cctggggacg gggcgcgga cgacggtgct ggagatggtg 840
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 ggggcctcaa tccccg 1516

<210> 16
 <211> 352
 <212> PRT
 <213> *Triticum aestivum*

<400> 16
 Ala Arg Gly Ser Val Leu Val Thr Gly Gly Ala Gly Phe Ile Gly Thr
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 20 25 30
 Asp Asn Phe His Asn Ser Val Pro Glu Ala Leu Asp Arg Val Arg His
 35 40 45
 Ile Val Gly Pro Ala Leu Ser Ala Arg Leu Gln Phe Ile Phe Gly Asp
 50 55 60
 Leu Thr Ile Lys Asp Asp Leu Glu Lys Val Phe Ala Ala Lys Lys Tyr
 65 70 75 80
 Asp Ala Val Ile His Phe Ala Gly Leu Lys Ala Val Ala Glu Ser Val
 85 90 95

Ala His Pro Glu Met Tyr Asn Arg Asn Asn Ile Val Gly Thr Val Asn
100 105 110

Leu Tyr Asp Val Met Lys Lys His Gly Cys Asn Lys Leu Val Phe Ser
115 120 125

Ser Ser Ala Thr Val Tyr Gly Gln Pro Glu Lys Val Pro Cys Phe Glu
130 135 140

Asp Ser Pro Leu Lys Ala Leu Asn Pro Tyr Gly Arg Thr Lys Leu Tyr
145 150 155 160

Leu Glu Glu Met Leu Arg Asp Tyr Gln His Ala Asn Pro Glu Trp Arg
165 170 175

Thr Ile Leu Leu Arg Tyr Phe Asn Pro Ile Gly Ala His Glu Ser Gly
180 185 190

Asp Ile Gly Glu Asp Pro Lys Gly Val Pro Asn Asn Leu Leu Pro Tyr
195 200 205

Ile Gln Gln Val Ala Val Ala Arg Arg Pro Glu Leu Asn Val Tyr Gly
210 215 220

His Asp Tyr Arg Thr Arg Asp Gly Thr Ala Val Arg Asp Tyr Ile His
225 230 235 240

Val Val Asp Leu Ala Asp Gly His Ile Ala Ala Leu Glu Lys Leu Phe
245 250 255

Ala Thr Pro Asp Ile Gly Cys Val Ala Tyr Asn Leu Gly Thr Gly Arg
260 265 270

Gly Thr Thr Val Leu Glu Met Val Ser Ala Phe Glu Lys Ala Tyr Gly
275 280 285

Lys Lys Ile Pro Val Lys Met Cys Pro Arg Arg Pro Gly Asp Ser Glu
290 295 300

Gln Val Tyr Ala Ser Thr Ala Lys Ala Glu Glu Glu Leu Gly Trp Arg
305 310 315 320

Ala Lys Tyr Gly Ile Glu Glu Met Cys Arg Asp Gln Trp Asn Trp Ala
325 330 335

Lys Lys Asn Pro Tyr Gly Tyr Cys Gly Asn Ala Ala Glu Asn Lys Asp
340 345 350

<210> 17

<211> 1393

<212> DNA

<213> Zea mays

<400> 17

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tactttatta tgacaacaac gtcattggca cgataaatct tctagaagtt atgtctgttc 180
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caccctgcac agaaaatttt cctcttactc caaacaatcc atatggcaaa acaaagctcg 300
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ttaggtactt caatccagtt ggtgctcatc ctagtggata tcttggcgag gacccacgag 420
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aaaaaaaaaa aaa                                     1393

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<210> 18
 <211> 353
 <212> PRT
 <213> Zea mays

<400> 18

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Thr Arg Ile Asp Leu Arg Asp Lys Gly Ala Leu Glu Met Val Phe Ala
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Ser Thr Arg Phe Glu Ala Val Ile His Phe Ala Gly Leu Lys Ala Val
          20             25             30

Gly Glu Ser Val Gln Lys Pro Leu Leu Tyr Tyr Asp Asn Asn Val Ile
          35             40             45

Gly Thr Ile Asn Leu Leu Glu Val Met Ser Val His Gly Cys Lys Lys
  50             55             60

Leu Val Phe Ser Ser Ser Ala Ala Val Tyr Gly Ser Pro Lys Asn Ser
  65             70             75             80

Pro Cys Thr Glu Asn Phe Pro Leu Thr Pro Asn Asn Pro Tyr Gly Lys
          85             90             95

Thr Lys Leu Val Val Glu Asp Ile Cys Arg Asp Ile Tyr Arg Ser Asp
          100            105            110

Pro Glu Trp Lys Ile Ile Leu Leu Arg Tyr Phe Asn Pro Val Gly Ala
          115            120            125

His Pro Ser Gly Tyr Leu Gly Glu Asp Pro Arg Gly Ile Pro Asn Asn
          130            135            140

Leu Met Pro Tyr Val Gln Gln Val Ala Val Gly Arg Arg Pro Ala Leu
          145            150            155            160

Thr Val Leu Gly Asn Asp Tyr Ala Thr Arg Asp Gly Thr Gly Val Arg
          165            170            175

Asp Tyr Ile His Val Val Asp Leu Ala Asp Gly His Ile Ala Ala Leu
          180            185            190

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Gln Lys Leu Phe Glu Asn Ser Ser Ile Gly Cys Glu Ala Tyr Asn Leu
 195 200 205

Gly Thr Gly Arg Gly Thr Ser Val Leu Glu Ile Val Lys Ala Phe Glu
 210 215 220

Lys Ala Ser Gly Lys Lys Ile Pro Leu Ile Phe Gly Glu Arg Arg Pro
 225 230 235 240

Gly Asp Ala Glu Ile Leu Phe Ser Glu Thr Thr Lys Ala Glu Arg Glu
 245 250 255

Leu Asn Trp Lys Ala Lys Tyr Gly Ile Glu Glu Met Cys Arg Asp Gln
 260 265 270

Trp Asn Trp Ala Ser Lys Asn Pro Tyr Gly Tyr Gly Ser Pro Asp Ser
 275 280 285

Ile Lys Gln Asn Gly His Gln Thr Asn Gly Ser Ala Asp Ser Ser Lys
 290 295 300

Gln Asn Gly His Arg Thr Asn Gly Ser Thr Asp Ser Pro Lys Arg Asn
 305 310 315 320

Gly His His Ala Tyr Gly Ser Ala Asp Ser Pro Lys Arg Asn Gly His
 325 330 335

Cys Val Phe Gly Ser Ser Asp Leu Lys Pro Asn Gly Asn Gly His Leu
 340 345 350

Arg

<210> 19
 <211> 1498
 <212> DNA
 <213> Oryza sativa

<400> 19
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 gccatcctcc gcgtcaggga actcgccgga cacaacgcca acaacctcga cttccgcaag 300
 gttgacctcc gcgacaagca agcgttggac caaatcttct cctctcaaag gtttgaggct 360
 gtcattccatt ttgccgggct gaaagctggt ggcgagagcg tgcagaagcc cctgctttac 420
 tacgacaaca acctcatcgg caccatcact ctctgcagg tcatggccgc acatggctgc 480
 accaagctgg tgttctcatc atccgcaact gtctacgggt ggcccaagga ggtgcctgc 540
 actgaagaat ccccactttg tgcaatgaac ccctacggca gaacaaagct ggtaatcgaa 600
 gacatgtgcc gggatctgca tgcctcagac ccaaactgga agatcatact gctccgatac 660
 ttcaacctg ttggagctca ccaagcggg tacattgggt aggaccctg cggcatccca 720
 aacaacctca tgcccttcgt ccagcagggt gctgttggca ggaggccggc ccttacgctc 780
 tatggaaccg actacaacac caaggatgga actgggggtc gtgactatat ccatgttggt 840
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 ggatgtgagg tgtacaatct gggcactgga aaggggacat ctgtgctgga aatggttgca 960
 gcattcgaga aagcttctgg aaagaaaatc ccgcttgat ttgctggacg aaggcctgga 1020
 gatgccgaga tcgtttacgc tcaaaactgcc aaagctgaga aggaactgaa atggaaggca 1080
 aaatacgggg tagaggagat gtgcagggac ctgtggaatt gggcgagcaa gaaccctac 1140
 gggatggtat cgccggacag tagcaactga tccagctgaa tataggcgct caatcctcca 1200


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gtagcagcag cagcagcatg acttctatac atatatatat ataatacataa agaatagaaga 1260
aacaaagaat tcggacttgt tgagttacta ctactactac tactaatccc atctgatgga 1320
ccgcattgta taggggggtt gtaggggtcc agcagcttca tcatcagtct ccttaggagg 1380
cctctaatat aatctccata tttatggtag aaataaattt tgcccaccgt ggaagaacta 1440
tataatagaa tcatgatgat ttgttgatta aaaaaaaaaa aaaaaaaaaa aaaaaaaaaa 1498

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<210> 20

<211> 354

<212> PRT

<213> *Oryza sativa*

<400> 20

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Met Val Ser Ala Leu Leu Arg Thr Ile Leu Val Thr Gly Gly Ala Gly
  1                      5                      10                      15

```

```

Tyr Ile Gly Ser His Thr Val Leu Gln Leu Leu Gln Leu Gly Phe Arg
                20                      25                      30

```

```

Val Val Val Leu Asp Asn Leu Asp Asn Ala Ser Glu Leu Ala Ile Leu
                35                      40                      45

```

```

Arg Val Arg Glu Leu Ala Gly His Asn Ala Asn Asn Leu Asp Phe Arg
  50                      55                      60

```

```

Lys Val Asp Leu Arg Asp Lys Gln Ala Leu Asp Gln Ile Phe Ser Ser
  65                      70                      75                      80

```

```

Gln Arg Phe Glu Ala Val Ile His Phe Ala Gly Leu Lys Ala Val Gly
                85                      90                      95

```

```

Glu Ser Val Gln Lys Pro Leu Leu Tyr Tyr Asp Asn Asn Leu Ile Gly
  100                      105                      110

```

```

Thr Ile Thr Leu Leu Gln Val Met Ala Ala His Gly Cys Thr Lys Leu
  115                      120                      125

```

```

Val Phe Ser Ser Ser Ala Thr Val Tyr Gly Trp Pro Lys Glu Val Pro
  130                      135                      140

```

```

Cys Thr Glu Glu Ser Pro Leu Cys Ala Met Asn Pro Tyr Gly Arg Thr
  145                      150                      155                      160

```

```

Lys Leu Val Ile Glu Asp Met Cys Arg Asp Leu His Ala Ser Asp Pro
  165                      170                      175

```

```

Asn Trp Lys Ile Ile Leu Leu Arg Tyr Phe Asn Pro Val Gly Ala His
  180                      185                      190

```

```

Pro Ser Gly Tyr Ile Gly Glu Asp Pro Cys Gly Ile Pro Asn Asn Leu
  195                      200                      205

```

```

Met Pro Phe Val Gln Gln Val Ala Val Gly Arg Arg Pro Ala Leu Thr
  210                      215                      220

```

```

Val Tyr Gly Thr Asp Tyr Asn Thr Lys Asp Gly Thr Gly Val Arg Asp
  225                      230                      235                      240

```

```

Tyr Ile His Val Val Asp Leu Ala Asp Gly His Ile Ala Ala Leu Arg
                245                      250                      255

```



Lys Leu Tyr Glu Asp Ser Asp Arg Ile Gly Cys Glu Val Tyr Asn Leu
 260 265 270
 Gly Thr Gly Lys Gly Thr Ser Val Leu Glu Met Val Ala Ala Phe Glu
 275 280 285
 Lys Ala Ser Gly Lys Lys Ile Pro Leu Val Phe Ala Gly Arg Arg Pro
 290 295 300
 Gly Asp Ala Glu Ile Val Tyr Ala Gln Thr Ala Lys Ala Glu Lys Glu
 305 310 315 320
 Leu Lys Trp Lys Ala Lys Tyr Gly Val Glu Glu Met Cys Arg Asp Leu
 325 330 335
 Trp Asn Trp Ala Ser Lys Asn Pro Tyr Gly Tyr Gly Ser Pro Asp Ser
 340 345 350
 Ser Asn

<210> 21
 <211> 1532
 <212> DNA
 <213> Glycine max

<400> 21
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 ccgaatatgg catcgcgcggt cagcattggc aaccttacct cctccgcgcc gtatatattaat 120
 tcccctcact ttcgctcacc acttaagatt tccaacaacc cctctctgca aaacgcttcg 180
 cataaggtac ttatgcgcga taagactgta ctggtaaccg gcggagccgg ttacatcggc 240
 agccacaccg ttcttcagct cttgctcggg ggtttcagag ccgtcgtcct cgacaacctc 300
 gaaaattcct ccgaggttgc catccacaga gtcagggagc tcgccggcga atttgggaac 360
 aacctctcct ttcacaaggt ggacctacgg gacagagctg ctctagacca aatattttct 420
 tccacacaat tcgatgctgt catacatttt gctggactga aagcagtagg agaaagtgtg 480
 caaaaacctt tactatacta taacaacaac ttgactggga caatcactct attggaagtc 540
 atggctgccc atggatgcaa gaagctcgtg ttttcactct cagcaactgt atatggttgg 600
 ccaaaggagg ttccatgcac agaagagttc cctctgtcag caatgaaccc atatggacga 660
 actaagctta tcattgaaga aatttgccgt gatgtccact gtgcagagcc agattgtaaa 720
 ataattttgt taagatactt caaccagtt ggtgcacacc ccagtgggta tattggggag 780
 gatcctcgtg gaattccaaa caatctcatg ccatttggtc agcaagtagc agttggccga 840
 cggcctgcac tgacagtttt tggaaatgat tataatacaa gtgatggcac tgggggttcgg 900
 gattacattc atgttggtga tttagcagat gggcacattg ctgcattgct taaactagat 960
 gaacctataa taggttggtga ggtttataac ctgggaacag gaaagggaaac atcagttttg 1020
 gagatgggta gagcttttga aatggcatct ggaaagaaaa ttccacttgt gatggctggc 1080
 cgtagacctg gtgatgctga aattgtttat gcatcaacaa agaaagcgga aagagagctt 1140
 aaatggaagg caaaatatgg cattgatgag atgtgccgtg atcaatggaa ttgggctagc 1200
 aaaaaccctt atggctatgg agatcagggc tccaccgatt aaccacttag ttttctcttt 1260
 ggttctttt ctgaactcac ccacaccgta gtccgtaggt cttgtgaatt tagttttccc 1320
 aaaagctttt ctttcttttag tgatcttaag gtgacaaagt acttgatta ttactattca 1380
 tagttacata gtaagtaagt agtggtttac tatactgtaa tttaaaggtt ctctaggttc 1440
 cttcttacag gttattgatt attagattcg gattctctca tgttccacat gaggcagcatc 1500
 ctgttttgta aatctaaatc acatgtttgt tt 1532

<210> 22
 <211> 349
 <212> PRT
 <213> Glycine max



<400> 22

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Met Arg Asp Lys Thr Val Leu Val Thr Gly Gly Ala Gly Tyr Ile Gly
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Ser His Thr Val Leu Gln Leu Leu Leu Gly Gly Phe Arg Ala Val Val
          20           25           30

Leu Asp Asn Leu Glu Asn Ser Ser Glu Val Ala Ile His Arg Val Arg
          35           40           45

Glu Leu Ala Gly Glu Phe Gly Asn Asn Leu Ser Phe His Lys Val Asp
 50           55           60

Leu Arg Asp Arg Ala Ala Leu Asp Gln Ile Phe Ser Ser Thr Gln Phe
 65           70           75           80

Asp Ala Val Ile His Phe Ala Gly Leu Lys Ala Val Gly Glu Ser Val
          85           90           95

Gln Lys Pro Leu Leu Tyr Tyr Asn Asn Asn Leu Thr Gly Thr Ile Thr
          100          105          110

Leu Leu Glu Val Met Ala Ala His Gly Cys Lys Lys Leu Val Phe Ser
          115          120          125

Ser Ser Ala Thr Val Tyr Gly Trp Pro Lys Glu Val Pro Cys Thr Glu
          130          135          140

Glu Phe Pro Leu Ser Ala Met Asn Pro Tyr Gly Arg Thr Lys Leu Ile
          145          150          155          160

Ile Glu Glu Ile Cys Arg Asp Val His Cys Ala Glu Pro Asp Cys Lys
          165          170          175

Ile Ile Leu Leu Arg Tyr Phe Asn Pro Val Gly Ala His Pro Ser Gly
          180          185          190

Tyr Ile Gly Glu Asp Pro Arg Gly Ile Pro Asn Asn Leu Met Pro Phe
          195          200          205

Val Gln Gln Val Ala Val Gly Arg Arg Pro Ala Leu Thr Val Phe Gly
          210          215          220

Asn Asp Tyr Asn Thr Ser Asp Gly Thr Gly Val Arg Asp Tyr Ile His
          225          230          235          240

Val Val Asp Leu Ala Asp Gly His Ile Ala Ala Leu Leu Lys Leu Asp
          245          250          255

Glu Pro Asn Ile Gly Cys Glu Val Tyr Asn Leu Gly Thr Gly Lys Gly
          260          265          270

Thr Ser Val Leu Glu Met Val Arg Ala Phe Glu Met Ala Ser Gly Lys
          275          280          285

Lys Ile Pro Leu Val Met Ala Gly Arg Arg Pro Gly Asp Ala Glu Ile
          290          295          300

Val Tyr Ala Ser Thr Lys Lys Ala Glu Arg Glu Leu Lys Trp Lys Ala
          305          310          315          320

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Lys Tyr Gly Ile Asp Glu Met Cys Arg Asp Gln Trp Asn Trp Ala Ser
 325 330 335

Lys Asn Pro Tyr Gly Tyr Gly Asp Gln Gly Ser Thr Asp
 340 345

<210> 23
 <211> 490
 <212> DNA
 <213> Triticum aestivum

<220>
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 <222> (73)

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<400> 23
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 ntgaccggcg gcnccgggta natcggcagc cacaccgtgc tgcagctgct cctgcagggc 120
 ttccgcgtcc tcgtagtcga cagcctcgac aacgcctccg aggaggccat ccgccgcgtc 180
 cgacaactcg ccaacgcccc gcaaaanagc ctcgacttcc gcaagggtgga ccttcgtgac 240
 aaggangcgc tcgaccaa atctctcctcc caaagggtatc ttcnactttt ttccgcaaaa 300
 aagaagtatc ttttttcgng cttattatta anaattaact atagtatatt attgagtcca 360
 caaattaaat gttgattnnt ccgtccgtcc cggccgctcg gccagccanc canccgtntc 420
 tgctgtctata gcaaatacga ctcccttcta tcagnatcgt ngtcgttngt aggtgtcaan 480
 cncctacgag 490

<210> 24
 <211> 103
 <212> PRT
 <213> Triticum aestivum

<220>
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 <222> (4)

<220>
 <221> UNSURE
 <222> (6)

<220>
 <221> UNSURE
 <222> (48)

<220>
 <221> UNSURE
 <222> (61)

<220>
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 <222> (74)

<220>
 <221> UNSURE
 <222> (86)



<220>

<221> UNSURE

<222> (90)

<400> 24

Thr Gly Gly Xaa Gly Xaa Ile Gly Ser His Thr Val Leu Gln Leu Leu
 1 5 10 15

Leu Gln Gly Phe Arg Val Leu Val Val Asp Ser Leu Asp Asn Ala Ser
 20 25 30

Glu Glu Ala Ile Arg Arg Val Arg Gln Leu Ala Asn Ala Pro Gln Xaa
 35 40 45

Ser Leu Asp Phe Arg Lys Val Asp Leu Arg Asp Lys Xaa Ala Leu Asp
 50 55 60

Gln Ile Phe Ser Ser Gln Arg Tyr Leu Xaa Leu Phe Ser Ala Lys Lys
 65 70 75 80

Lys Tyr Leu Phe Ser Xaa Leu Leu Leu Xaa Ile Asn Tyr Ser Ile Leu
 85 90 95

Leu Ser Pro Gln Ile Lys Cys
 100

<210> 25

<211> 350

<212> PRT

<213> Pisum sativum

<400> 25

Met Val Ala Ser Ser Gln Lys Ile Leu Val Thr Gly Ser Ala Gly Phe
 1 5 10 15

Ile Gly Thr His Thr Val Val Gln Leu Leu Asn Asn Gly Phe Asn Val
 20 25 30

Ser Ile Ile Asp Asn Phe Asp Asn Ser Val Met Glu Ala Val Glu Arg
 35 40 45

Val Arg Glu Val Val Gly Ser Asn Leu Ser Gln Asn Leu Glu Phe Thr
 50 55 60

Leu Gly Asp Leu Arg Asn Lys Asp Asp Leu Glu Lys Leu Phe Ser Lys
 65 70 75 80

Ser Lys Phe Asp Ala Val Ile His Phe Ala Gly Leu Lys Ala Val Gly
 85 90 95

Glu Ser Val Glu Asn Pro Arg Arg Tyr Phe Asp Asn Asn Leu Val Gly
 100 105 110

Thr Ile Asn Leu Tyr Glu Val Met Ala Lys His Asn Cys Lys Lys Met
 115 120 125

Val Phe Ser Ser Ser Ala Thr Val Tyr Gly Gln Pro Glu Lys Ile Pro
 130 135 140

Cys Val Glu Asp Phe Lys Leu Gln Ala Met Asn Pro Tyr Gly Arg Thr
 145 150 155 160
 Lys Leu Phe Leu Glu Glu Ile Ala Arg Asp Ile Gln Lys Ala Glu Pro
 165 170 175
 Glu Trp Arg Ile Val Leu Leu Arg Tyr Phe Asn Pro Val Gly Ala His
 180 185 190
 Glu Ser Gly Lys Leu Gly Glu Asp Pro Arg Gly Ile Pro Asn Asn Leu
 195 200 205
 Met Pro Tyr Ile Gln Gln Val Ala Val Gly Arg Leu Pro Glu Leu Asn
 210 215 220
 Val Tyr Gly His Asp Tyr Pro Thr Arg Asp Gly Ser Ala Ile Arg Asp
 225 230 235 240
 Tyr Ile His Val Met Asp Leu Ala Asp Gly His Ile Ala Ala Leu Arg
 245 250 255
 Lys Leu Phe Thr Ser Glu Asn Ile Gly Cys Thr Ala Tyr Asn Leu Gly
 260 265 270
 Thr Gly Arg Gly Ser Ser Val Leu Glu Met Val Ala Ala Phe Glu Lys
 275 280 285
 Ala Ser Gly Lys Lys Ile Ala Leu Lys Leu Cys Pro Arg Arg Pro Gly
 290 295 300
 Asp Ala Thr Glu Val Tyr Ala Ser Thr Ala Lys Ala Glu Lys Glu Leu
 305 310 315 320
 Gly Trp Lys Ala Lys Tyr Gly Val Glu Glu Met Cys Arg Asp Gln Trp
 325 330 335
 Asn Trp Ala Lys Asn Asn Pro Trp Gly Tyr Ser Gly Lys Pro
 340 345 350
 <210> 26
 <211> 350
 <212> PRT
 <213> Cyamopsis tetragonoloba
 <400> 26
 Met Ser Ser Gln Thr Val Leu Val Thr Gly Gly Ala Gly Tyr Ile Gly
 1 5 10 15
 Ser His Thr Val Leu Gln Leu Leu Leu Gly Gly Phe Lys Ala Val Val
 20 25 30
 Val Asp Asn Leu Asp Asn Ser Ser Glu Thr Ala Ile His Arg Val Lys
 35 40 45
 Glu Leu Ala Gly Lys Phe Ala Gly Asn Leu Ser Phe His Lys Leu Asp
 50 55 60
 Leu Arg Asp Arg Asp Ala Leu Glu Lys Ile Phe Ser Ser Thr Lys Phe
 65 70 75 80

3

7

7

<400> 27
catggaggag cag

13

<210> 28
<211> 9
<212> DNA
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence:oligonucleotide

<400> 28
ctgctcctc

9



7

2

4

5